BLACK DIAMOND
ADVANCED TECHNOLOGY

Advancements in Wearable Computing Solutions

Treating the War Fighter as a System

1. Introduction

Dismounted war fighters have precise missions to perform in often dangerous conditions and rapidly evolving situations. Although military commanders have access to a common operating picture of their command ports and mounted elements in their areas of responsibility, they have minimal visibility and digital command and control of dismounted squads and platoons. Dismounted forces also have limited digital situational awareness of the forces in their immediate vicinity. These capability gaps persist, despite initial efforts to address them with soldier-borne solutions, limiting the effectiveness of wartime operations against an elusive and resourceful enemy.

While software and technological support to close these basic capability gaps has been tested with overall operational success, the lack of integration of the technology into the dismounted soldier's common equipment load-out has been an obstacle resulting in surplus gear for the war fighter, inefficiencies in combat zones and compromised safety.

Black Diamond Advanced Technology, together with Juggernaut Defense and Diamondback Tactical, is redefining the future of combat computer hardware by developing a lightweight, wearable and rugged computer system that treats the war fighter as a system and integrates into the user's common equipment load-out regardless of the mission.

The system concept allows a war fighter to transition from computer operation to direct combat engagement in seconds with a wearable system that is non-intrusive, allows easy access to other equipment and does not hinder field activities. Since the computer is integrated into a compact, vest-based system, it is easily accessible when needed. The war fighter never needs to stop, put down gear and lose time in a stationary position while powering up or repacking gear. When the computer is not needed, it is stowed in the vest and out of the soldier's way.

2. War Fighter Challenges

The average ground soldier carries between 63 and 130 pounds[1] (29 – 59 kg) of gear, depending on the mission. That's a significant load to carry for an extended period during the best of times and can result in musculoskeletal injuries, slowed speed and response times, decreased range of motion, and increased fatigue, all of which yield in decreased morale. In combat situations, where the ability to move quickly and maneuver with agility and precision is imperative, every extra ounce or gram of weight added to a war fighter's load is to be considered carefully as it could mean the difference between life and death.

The volatile nature of the battlefield demands both vigilance and the ability for war fighters to react quickly to evolving situations. Time spent packing gear or powering on equipment translates to wasted time when every second counts. Tools provided to war fighters must enhance their operations in the theater of war, without being obtrusive or hindering in any way their ability to survive or complete a mission.

As militaries worldwide move toward soldier modernization programs, computer technology has taken a leading role in military ground operations. Wearable systems have emerged as a critical investment to improve situational awareness, protect friendly forces and exert precision lethal force.

1 Thomas, Jen. "Heavy gear hampers troops in Afghanistan." Medill Reports. http://news.medill.northwestern.edu/washington/news.aspx?id=133013. June 3, 2009.

3. Lessons Learned

Building on lessons learned over the past four years from trials and exercises—including Future Force Warrior; Land Warrior; AFSOC, Summer Camp 2008 and 2009; training exercises with USASOC in Ft. Bliss, Texas; and contracted projects with the U.S. Army and Israeli Defense Force—the Black Diamond team explored better human factors for computing. Among our findings:

- A more ergonomic solution for providing the Human Machine Interface (HMI) for the dismounted user is critical.
- Modular options for the HMI interface are imperative for different missions, including overt or covert, and handheld or hands-free.
- The system must fit into and within existing equipment including packs, body armor, radios, ammunition, hydration, tools, etc.
- Improvements in computing performance including better 2D and 3D graphics, increased memory and adaptable input/output options are needed.
- Provisions for modular solutions in which COTS hardware can be packaged "in the box" should be made.
- Information assurance designed into the product with layered levels of security boundaries is essential to ensure critical information is not lost if the computer system falls into the wrong hands.
- Size, weight, power, performance and price are key performance parameters. Careful balance of these parameters is essential to optimize the best possible solution for the war fighter.
- Increase system reliability over the operational environments.

4. The War Fighter as a System

The idea of treating the war fighter as a system revolves around modifying and integrating the subsystems—body armor, hydration, communications, situational awareness and power—to make the computer work within the entire system. Size and weight can be reduced when looking at the entire system rather than only the computer. Instead of forcing a disparate computer box into the gear a war fighter carries—which results in a larger size and more weight—this system design allows all the elements to be integrated by modifying elements such as the armor carrier, but also by maintaining the integrity of critical elements like ESAPI plates. The result is a lightweight, non-intrusive system that is properly distributed and balanced on the body, and is easily accessible when needed.

While most available rugged computer systems on the market today are either a traditional laptop or tablet design, the Black Diamond team's system deconstructs the computer to fully integrate it into the war fighter's system without adding bulk or complicated assembly. (See Figure 1) The computer's processing platform and battery are carried in specially designed pouches on the rear of the pack, which creates an overall large flat surface on the back. This allows for a comfortable sitting position while mounted or for a more balanced day pack when worn on the back. A day pack is adaptable to hold a single Harris 117G or two Harris 152 radios, as well as two hydration bottles and additional gear.

The Hand Held Display (HHD) touch screen is secured behind ammunition magazine pouches in a custom, low-profile flip-down panel in the abdomen area on the front of

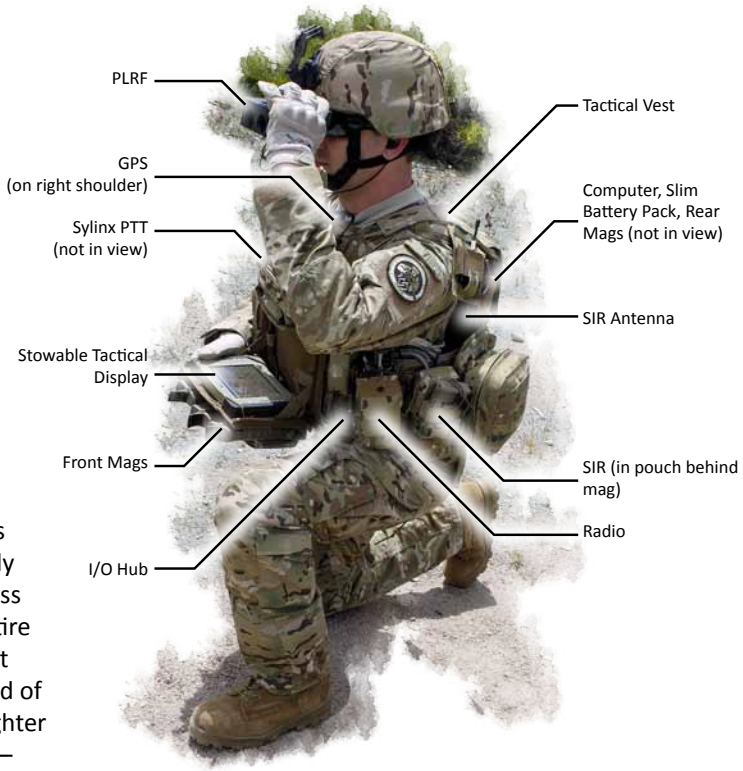

Figure 1 – Basic components of Black Diamond's wearable system

the vest. This allows for quick access to a large display for more advanced mission needs and situational awareness updates.

A GPS module is held in a small pouch on the shoulder, giving ideal satellite reception while maintaining doffing capability of both the day pack and the tactical vest. Cable routing to all peripherals (i.e., battery, I/O hub, display, GPS, etc.) is hidden within specially designed areas of the vest to maximize comfort and stealth and minimize snag hazards. An I/O hub, worn on the side cummerbund, provides easily accessible additional interfaces for connecting ad hoc peripherals such as a camera, an external hard drive and targeting devices, It also provides an audio interface for connecting a headset and a power interface for connecting an additional battery or external power.

4.1 Physical Considerations

Using principles of the U.S. Army's Manpower and Personnel Integration (MANPRINT) program, Black Diamond's wearable solution takes into account the soldier's physical interface with the computer. The wearable system is integrated into the vest because weight distributed at the body's core has the least impact on the soldier's mobility. It is also ideal for cables and other gear that could be damaged from repeated movement. The transitional zone just beyond the core area should be constrained to small, lightweight items and peripherals like IR strobes.

Care was taken in designing the wearable system to avoid the limb/active zone areas as weight in this area results in faster fatigue and less maneuverability. Additional weight strapped on arms or legs strains the user's limbs with prolonged use and impedes a soldier's ability to navigate their surrounding environment. Additionally, managing cable to these areas becomes more difficult, increases the hazard of cable snags and can weaken the integrity of the equipment from constant motion.

Screen size threshold is an important factor in choosing a display that is large enough to accurately evaluate data while being small enough to integrate as a wearable device. In Black Diamond's research, end users have stated that a display of less than 4 inches (9 cm), like those found on popular mobile phones, is too small for their requirements. Display size must be optimized for the best situational awareness given the mission profile. A screen size of approximately 6 inches (15 cm) allows for ease of viewing

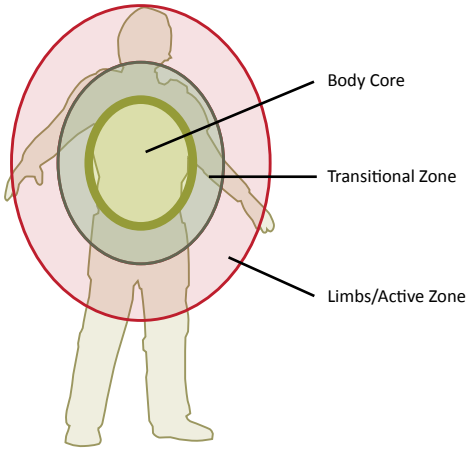

Figure 2 – MANPRINT principles

maps and geographical data, are viewable from a distance, and allow for use with a gloved hand. The trade off with larger screens upwards of 10 inches (25 cm) is lack of portability and weight.

4.2 Technical Aspects of the System

The Hand-Held Display (HHD) is the main user interface to the wearable computer and allows the war fighter to control the system while maintaining access to all other equipment. It is MIL-STD-3009 (NVIS) radiance compliant. The more than 6-inch (15 cm) diagonal, resistive touch screen LCD has a resolution of 1024 x 768 pixels and is sunlight viewable. Sewn-in webbing supports in the vest keep the display at approximately 80 degrees to an operator's line of sight. Weighing about a pound (455 g), its slim design is less than an inch thick and measures approximately 8 inches (20 cm) at its widest. In addition to left and right mouse, power, and soft keyboard toggle (on/off) buttons, there are five user-defined buttons. A tethered stylus is included. With easy-access buttons and programmable hot buttons that allow for functions like push-to-talk, voice recording and play back, and speech control over the computer system's speech recognition program, the system literally puts mission-critical tools at the soldier's fingertips.

The computing platform is based on Black Diamond's ultra-rugged, combat-proven SwitchBack™ computer, integrates COTS parts and products where possible for the lowest cost, and is designed for flexibility and usability. The tactical computing module runs on an Intel® Penryn Celeron® M 1.2 GHz processor with 120GB rotating or 64GB solid-state HDD support. Ports include two USB 2.0, gigabit Ethernet,

HHD NTSC/PAL and external battery. The tactical computing module weighs about 2 pounds (1 kg). Both the computing module and HHD are MIL-STD 810G and MIL-STD 461.

A hot-swappable battery in the main computing platform combined with an external battery provide for a charge that lasts a mission life of approximately 8 hours with 100-percent activity and up to 24 hours with low duty-cycle use. Batteries can be changed without loss of power or data. In recent trials, the system powered for active use for about 5 hours with a 40-percent charge remaining.

The tactical vest (see Figure 3) has a slim profile and serves as the central platform integrating armor, hydration, C4ISR capabilities and load bearing. Modular protection is designed to carry hard armor plates in the front and rear and includes permanently enclosed soft armor in the front and rear. Extra protection is available through the addition of ballistic panels in the shoulder, side plate pockets and cummerbund. The vest allows for a full load out of magazines without interfering with the operator's ability to get to their ammunition. Enhanced shoulder straps support weight over an extended period of time.

4.3 Benefits to the Dismounted War Fighter

Using current non-integrated and non–wearable technology, when a war fighter needs to access computer technology, the soldier must find a secure position, remove gear and power up the technology, all while maintaining situational awareness. If the unit falls under enemy fire or their position is otherwise compromised, they must secure their position while repacking gear or risk leaving it in enemy hands.

Figure 3 – Front and rear view of the tactical vest

The integrated, wearable system gives the war fighter several advantages, including the ability to:

- Switch between computer operations to weapons in seconds;
- Interface with targeting/mapping software (such as FalconView) and provide a remote operational terminal for the radio systems on his feet while moving;
- Operate the computer without putting down or unpacking any gear;
- Complete Close Air Support (CAS) missions quickly—simply unzip the HHD compartment, hit a button and go;
- Track friendly forces in real time;
- Minimize exposure by accomplishing the mission faster;
- Maneuver through rugged terrain with a lightweight pack and without compromising the integrity of computer hardware and sensitive data;
- Easily access computer when needed and stow it out of the way when not being used;
- Move in and out of combat zones more quickly by any necessary method; and
- Optimize the in-field use and reduce weight with a system that allows for capabilities in different power states, thereby maximizing the power mission profile.

5. Conclusion

The core of this technology already has proved its usefulness in combat, especially in pinpointing targets, increasing situational awareness and reducing human error. What an integrated wearable system can do for dismounted war fighters is essentially a game-changer in the theater of operations because the technology is more useful, less cumbersome and more maneuverable. Treat the soldier as a system and package wearable computing system as an integral part of their equipment, and size becomes less of a concern as it disappears into the equipment rather than being another box they have to stick somewhere.

The key to making the war fighter successful is taking a holistic and modular approach to the design of the wearable system and treating the soldier as a system, rather than adding to their already heavy loads.

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