BLACK DIAMOND
ADVANCED TECHNOLOGY

Advancements in Wearable Computing Solutions Aid JTAC Missions

1. Introduction

The role of the Joint Terminal Attack Controller (JTAC) requires the successful completion of precise, time-sensitive missions in often dangerous conditions and rapidly evolving situations. Theirs is a multi-mission, high-stress and high-value position in a complex battlefield with no real frontline and against an elusive enemy with the ability to blend into the civilian population in moments.

Because JTACs serve multiple, simultaneous missions, they must carry the equipment required for the JTAC mission—such as computers, range finders and Video Down Link (VDL) receivers for situational awareness (SA) and intelligence, surveillance and recognizance (ISR)—along with the armor, hydration, communications gear and weapons required for their additional missions. While software and technological support to address JTAC Close Air Support (CAS) missions have been tested with overall operational success, the lack of equipment integration into the JTAC's common equipment load-out has been an obstacle resulting in surplus gear for the JTAC, inefficiencies in combat zones and compromised safety.

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

The Black Diamond Modular Tactical System (MTS) wearable configuration solves issues of size, weight and power; power source complexity; urgency of ongoing combat operations; and security, all while providing true mobile C4ISR and being flexible for additional missions.

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 JTAC 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 individual's way.

2. JTAC Challenges

The average ground soldier carries between 63 and 130 pounds[1] (29 – 59 kg) of gear, depending on the mission, with JTACs often carrying gear weighing in the upper range. 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 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.

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

Although they share certain challenges with other dismounted soldiers, JTACs face unique battlefield challenges due to their multi-functional role and highly specialized missions. In addition to completing missions as part of their unit, they are entrusted with ensuring the safety of aircrews, accurately putting bombs on target, knowing the location of friendly forces and threats, and directing flight paths so that bombs are never overhead of friendly forces. Situational awareness is paramount to the completion of the objective and there is little room for human error, yet the majority of the complex calculations needed to deliver target information are done with a map, compass, pencil, radio, laser rangefinder and handheld SAASM GPS (DAGR, PLGR) under high stress and within a limited timeframe. Even a minor error could result in a failed mission or loss of life.

From a timing perspective, missions must be completed as quickly as possible to account for movements of friendly forces, threats and targets. In the best of circumstances—when the aircraft is on station to support and all other factors in the JTAC's favor—manual calculation for even the most experienced JTACs still takes approximately 15 minutes, at best, to put effects on target.

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. For JTACs, this signifies an evolution from paper and pencil to full digital CAS or digitally aided CAS.

Still, digital CAS on the battlefield has to be a highly coordinated activity. The correct aircraft—equipped with the proper data links—must be overhead and supporting the given mission when the JTAC has the same data link interface with his gear. Only then is a full digital CAS mission plausible. Since most NATO aircraft are not equipped with the same or common data link, the probability of a full digital CAS mission happening on a time-sensitive target is low, although this is increasing.

3. Lessons Learned

Building on lessons learned over the past five years from trials and exercises—including Future Force Warrior; Land Warrior; Nett Warrior, Bold Quest, Summer Camp 2008 and 2009; training exercises with USASOC in Ft. Bliss, Texas; contracted projects with the U.S. Army and Israeli Defense Forces; prototype testing at Elgin AFB; operational use of prototype systems by U.S. Special Forces for Operation Enduring Freedom in Afghanistan—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.
- The system must fit into and within existing equipment including packs, body armor, radios, ammunition, hydration, tools, etc.
- Provisions for modular solutions in which COTS hardware can be packaged "in the box" should be made.
- 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.
- Stressful situations affect cognition. Simplistic human-machine interaction with intuitive menus and large buttons are necessary to mitigate negative effects.
- Increase system reliability over the operational environments.
- Improvements in computing performance including better 2D and 3D graphics, increased memory and adaptable input/output options are needed.
- 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.

4. The JTAC as a System

Black Diamond Advanced Technology's goal in developing the MTS was to approach the wearable computer solution as a complete system. The idea of treating the JTAC as a system endeavors to provide true "on-the-move" performance and situational awareness with a solution that is integrated into the uniform and gear, provides interoperability with existing system elements, and is flexible for additional missions. This includes not only the computer and display, but all the gear necessary for the modern day war fighter. Size and weight can be reduced when looking at the system as a whole, rather than a single component.

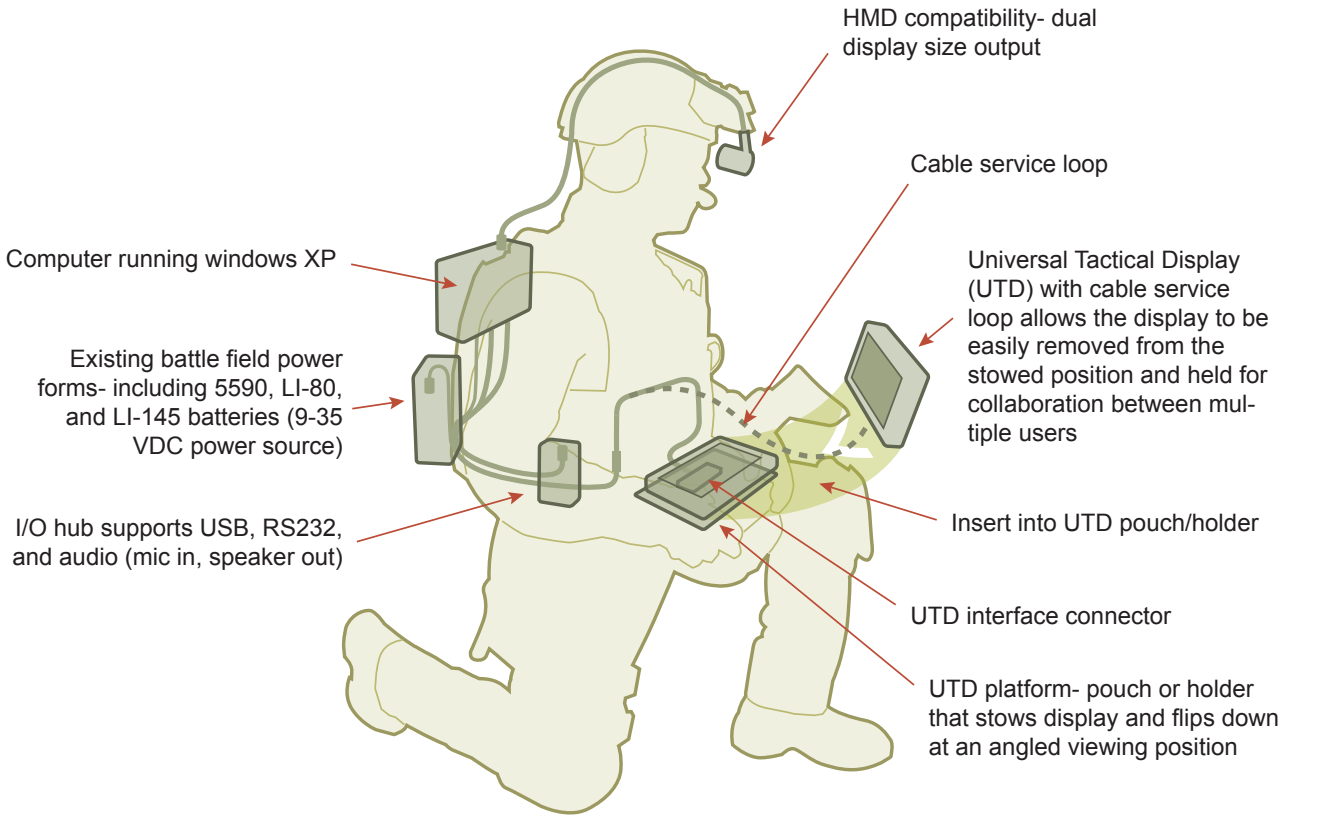

Figure 1 – The MTS Approach

By modifying and integrating the subsystems—body armor, communications, power, situational awareness, munitions and hydration—the computer works within the entire system. 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 MTS deconstructs the computer to fully integrate it into the war fighter's system without adding bulk or complicated assembly. Using a vest-based configuration, the computer's low-profile processing platform is carried on the rear of the pack. Cables are routed through an interchangeable cummerbund that integrates body armor and is secured to the vest. A flip-down front pocket opens quickly for access to the removable 6.5-inch Universal Tactical Display (UTD) and maintains a low profile in the stowed position. Power is sourced from existing standard military batteries including 5590, LI-80 and LI-145. (See Figure 1)

By sourcing power from existing batteries; intelligently routing cables; and allowing all communications, navigation, ISR and C2/SA computing functionality to share a single display, Black Diamond's MTS eliminates up to 15 pounds of weight for the JTAC, depending on the configuration.

4.1 Modularity of the MTS

The MTS is modular in design, allowing the JTAC flexibility to choose only the gear needed for mission planning as well as execution. The JTAC can choose to wear the patent-

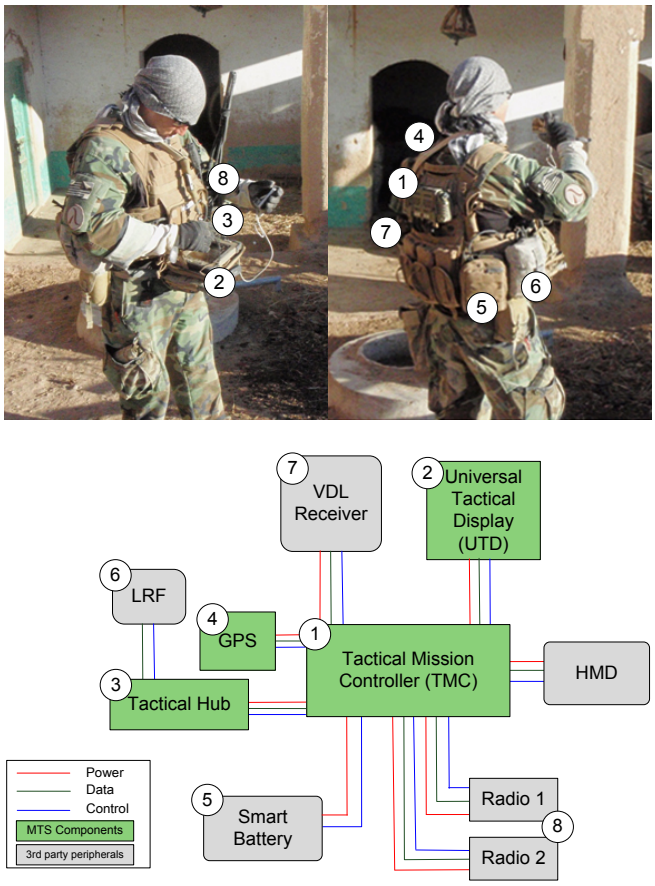

Figure 2 – MTS Power, Data, and Control

pending cummerbund with cable routing features for a mission that includes using the MTS to call in airstrikes or can choose a second cummerbund without cabling for missions when the MTS is not needed. The MTS also supports multiple displays, including helmet-mounted, hands-free and wrist-mounted displays.

For longer missions or those requiring additional radios, JTACs can strap on the Extended Radio Pack, which is worn over the Tactical Mission Controller and plate carrier, and holds AN/PRC-117F/G, AN/PRC-150, MBITR/PRC-152 (with reach back Amplifier), ERPLRS RT-1922 or PRC 7800S radios. Connecting to the TMC is achieved by a quick-connect coupling over the shoulder. The pack also includes an integrated hydration system and extra storage compartments.

The MTS can run off virtually any power source ranging from MIL-STD 1275 9 – 35 volts, including LI-145/80, BA 5590, solar power, fuel cells and vehicle power. This means the MTS is battery agnostic; it works with the standard military batteries already available in mass supply. With the exception of a system back-up battery, no other battery is needed for the system and attached peripherals that can be externally powered from the TMC directly.

Interoperability With Fielded Equipment and Software

The MTS is interoperable with fielded equipment and software that can share and be operated by a single display. These include:

Radios:
- PRC-152
- PRC-117
- PRC-148
- RT-1922
- RF-7800S

Navigation:
- DAGR SAASM GPS receiver

ISR (Video Data Links):
- MVRIV
- L3 SIR
- Harris 7800T

C2/SA:
- FBCB2 JCR-V
- TACP CASS
- BAO Suite
- StrikeLink
- Falcon View
- PSS-SOF

Both the vest and extended radio pack are covered with MOLLE or PALS webbing for attaching mission-critical gear.

4.2 MTS Components

The Tactical Mission Controller (TMC)—which utilizes an Intel® Atom™ 1.6 GHz processor with 2GB RAM, an embedded removable solid state drive, and removable SD card for sensitive mission data—attaches to the back of the vest via MOLLE. A hands-free display connector and commercial GPS connector exit the TMC near the shoulders for easy access. All other I/O ports exit the bottom of the Tactical Mission Controller and route into the vest. Because the cables are permanently routed through the proprietary cummerbund and covered, they offer higher reliability and longevity, better comfort to the user and minimized snag hazards.

The low-profile Universal Tactical Display (UTD) is stowed in a pocket and attached via MOLLE to the front panel, without compromising access to ammunition magazine pouches. Once secured to the vest, the pocket flips opens to display the sunlight-viewable, 6.5-inch screen at approximately 80 degrees to the operator's line of sight. This allows for quick access to a large display for more advanced mission needs and situational awareness updates and maintains a low profile in the stowed position. The display can also be quickly removed for collaborative tasks or hand-held use.

The resistive touch screen UTD features a resolution of 1024 x 768 and includes an on-screen keyboard, five user-defined buttons, and optical mouse with left and right click. Because the MTS allows all communications, navigation, ISR and C2/SA computing functionality to share and be operated by a single display, these peripherals do not need to be attached to PALS webbing and can instead be stowed in the back of the vest.

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 UTD literally puts mission-critical tools at the soldier's fingertips.

Both the TMC and UTD meet requirements for MIL-STD-810G and MIL-STD-461F and are sealed to IP67, meaning they are completely dust resistant and can be submersed in up to 1 meter of water. The combined weight of the TMC and UTD is less than 3.5 pounds, while certain configurations weigh in at just 1.8 pounds. The controller measures about 7 × 3.5 × 1.5 inches and the display measures about 8.3 × 5.8 × 0.9 inches.

In addition to being lightweight and unobtrusive, the TMC and UTD provide safety advantages in the field. In night vision goggle (NVG) mode, the UTD produces no detectable light beyond 10 meters. The TMC and UTD also stay relatively cool, with a heat signature similar to a person's body temperature. See Figures 3 and 4.

A MOLLE-compatible Tactical I/O Hub provides easily accessible additional interfaces for connecting ad hoc peripherals such as biometric capture devices, targeting systems such as the PLRF-15C, cameras, and external hard drives. It also provides an audio interface for connecting a

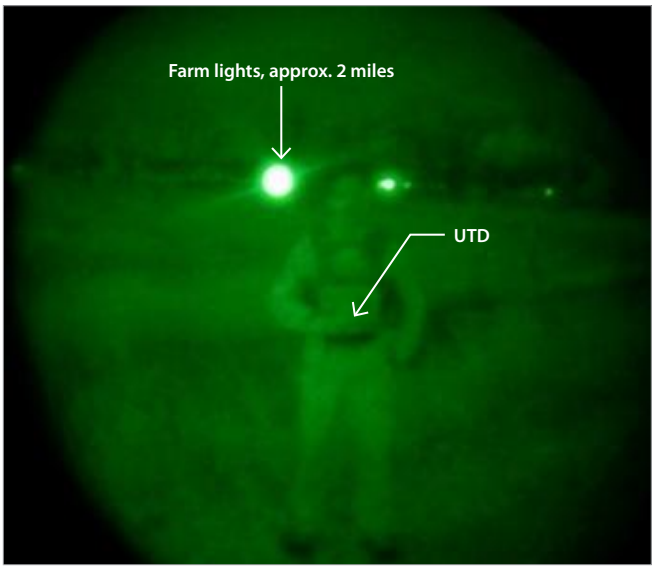

Figure 3 – MTS NVG Mode

As seen through night vision goggles, the UTD produces no detectable light beyond 10 meters when in NVG-mode. Utilized PVS-14 and PVS-15 night vision goggles in cold, dark night conditions. Crescent moon, low on horizon.

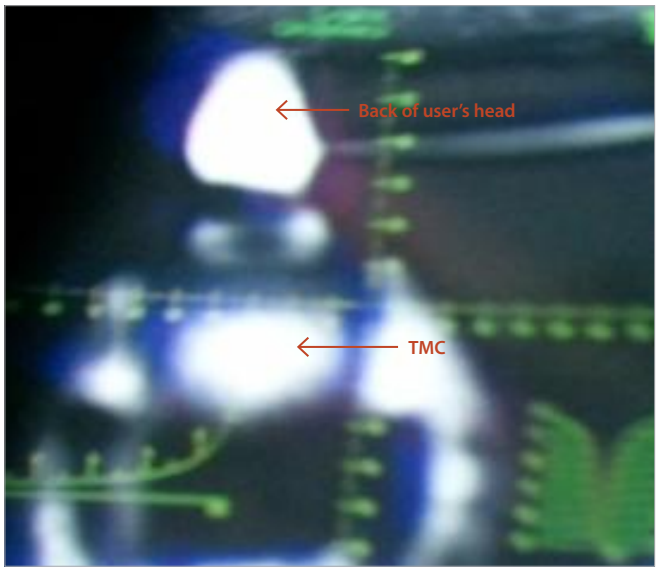

Figure 4 – MTS Heat Signature

This image shows that the heat signature of the MTS Tactical Mission Controller is similar to that of a person's body temperature.

headset and an interface for connecting to external power sources for topping off system batteries. The Tactical I/O Hub also meets the same environmental standards as the TMC and the UTD.

A GPS module is held in a small pouch on the shoulder, giving ideal satellite reception while maintaining doffing capability of both the tactical vest and the extended radio pack.

4.3 Physical Considerations

Black Diamond's wearable solution takes into account the JTAC'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.

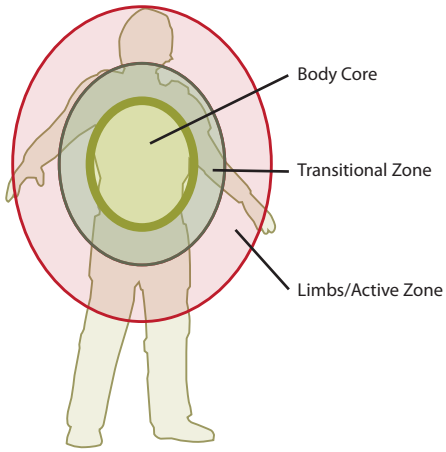

Figure 5 – Designing for the Human Body

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 JTAC's ability to navigate their surrounding environment. Additionally, managing cables 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. Display size must be optimized for the best situational awareness given the mission profile. A screen size of approximately 6 inches (15 cm) allows ease of viewing maps and geographical data, is viewable from a distance, can be used for multitasking, and allows for operation with a gloved hand. The trade off with larger screens upwards of 10 inches (25 cm) is lack of portability and weight.

Consider the example in Figure 6, which shows the same map (without any scaling) shown in various display sizes. Fewer waypoints are in view as the screen size gets smaller. This demonstrates how situational awareness is degraded using a display that does not allow the user to properly interpret the data.

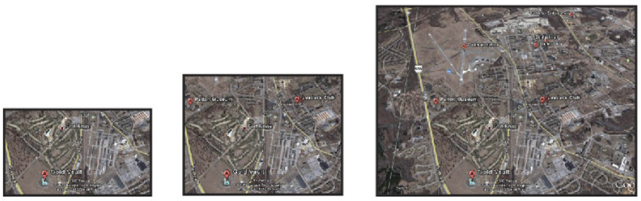

Figure 6 – Screen Size Trades

Left to right: 5.6-inch (14.2 cm) display, 6.5-inch (16.5 cm) display, 10.4-inch (26.4 cm) display. More waypoints are visible as the screen size increases.

4.4 Human/Machine Interface

In today's complex battlefields, there are no real front lines and the enemy blends into the civilian population in moments, making targets extraordinarily time sensitive. A system that can offer true mobile C4ISR and the benefits of digitally aided Close Air Support (CAS), can increase lethality and reduce both fratricide and collateral damage. In order to reap these benefits, the system needs to optimize the human/machine interface.

In designing the MTS, Black Diamond accounted for the JTAC's need to accomplish multiple missions in an abbreviated timeline and under mounting stress. The MTS can be used while standing or even walking, with no setup time and a reduced need to establish security. This allows for quick ingress and egress out of a location.

The patent-pending Human Machine Interface software is optimized for use under stress. The quick-launch application provides large icons and shortcut buttons in a

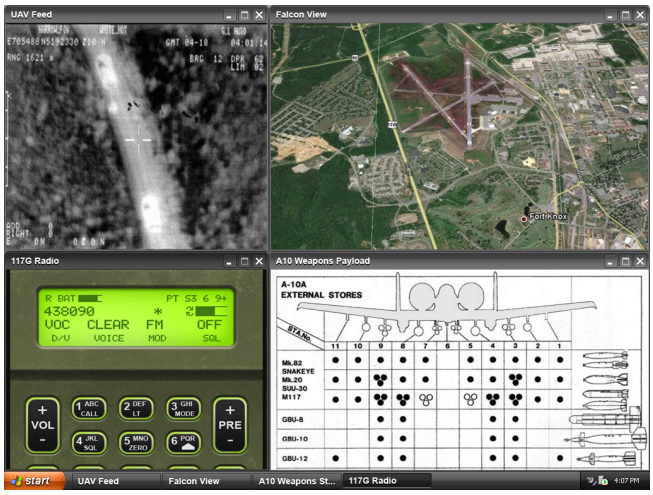

Figure 7 – Tiled Applications for Improved SA

simple interface similar to a smart phone menu, but with the power of a full desktop computer system. On the 6.5-inch display, which is intended for multitasking, the JTAC can tile multiple applications (see figure 7), allowing the individual to manage communications, VDL feeds and targeting on a single screen.

An additional advantage of having the computer system, radio, and VDL capability integrated into one system is that it allows the JTAC to record voice communications from radio traffic while simultaneously recording VDL feeds from a UAV for better command and control, AAR and mission training.

5. Benefits to the JTAC

Currently, when a JTAC needs to call in an airstrike, he has two choices: 1) find a relatively secure position to set up gear for manual computation, or 2) find a relatively secure position, remove the non-integrated and non-wearable computer technology, and power up the equipment for computer-aided calculations. All of this must be done while maintaining personal situational awareness and takes considerable time. If the unit falls under enemy fire or their position is otherwise compromised, JTACs must defend their position while repacking gear or risk leaving it in enemy hands.

While JTACs will always need to understand the math and mapping of the Military Grid Reference System (MGRS) and computer-based calculations will never fully replace manual computations or supersede the importance of voice-to-voice contact, there are advantages to employing technology for this task.

The integrated, wearable MTS gives the JTAC several distinct advantages, including the ability to:

- Switch between computer operations to weapons and back again in seconds
- Interface with targeting/mapping software to calculate exact target coordinates while standing or moving, if necessary
- Reduce the time needed to calculate a target point from an estimated 15 minutes if done manually to fewer than 30 seconds using the MTS
- Reduce human error
- Operate the computer without putting down or unpacking any gear
- Run existing government software including FalconView, TACP CASS, Rosetta, AFATDS and FBCB2, new software such as Pashto Language Translation and Soft Radio control and commercial software like Dragon Naturally speaking
- Complete Close Air Support (CAS) missions quickly—simply unzip the Tactical Display 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 the 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
- Carry only what the soldier needs for a particular missio
- View and control all communications, navigation , ISR and C2/SA computing functionality on a single display
- 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.

6. Additional Considerations for Cost, Urgency and Security

A single display and battery not only lower the weight of the device, they have the added benefit of reducing the overall cost to outfit a JTAC. Cable management through the cummerbund helps reduce future costs by protecting the cable from repeated movements, which can weaken the cable over time.

Given the urgency of ongoing combat operations, an Off-the-Shelf (OTS) system with no development required is the fastest and least expensive way to deploy a system with the potential to enhance battlefield C4ISR and save lives. The MTS is currently at Technology Readiness Level (TRL) 9 and can address urgent needs statements.

With some OTS systems, a major limitation is a lack of security features. Adding them aftermarket drives up development costs and slows deployment. The MTS is equipped with layered security features including zeroize capability and active tamper detection.

7. 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 like the MTS can do for JTACs 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 the 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 must add to their already heavy loads.

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