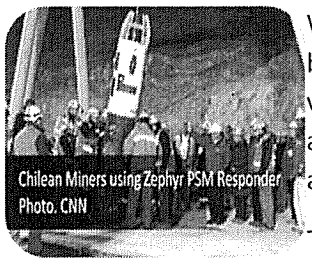
In-Q-Tel Quarterly: What Are Wearables?



Wearables are sensor devices that quite literally are worn on the physical body. A wearable device can be worn by someone while his or her different vital signs are being tracked and transmitted to another location for various applications. To make a wearable sensor valuable it must be integrated into a larger system.

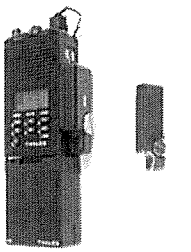
Three components make a wearable system, the sensor, the transmission of data being recorded by the sensor, and the actual display of that data which should turn the data into actionable information. Smart Wearables use local high resolution data to make decisions and relay actionable information to decision-makers in a timely and bandwidth friendly manner.

An integrated system solution provides command and control passive knowledge of force readiness, and exception-based actionable information when indications are trending negative or have reached emergency alert levels. This integrated system solution, referred to as Physiological Status Monitoring (PSM) is an area of Wearables that has been co developed and fielded for the last decade in various groups within the DoD and Government agencies. Typically these groups have been limited to small numbers tasked with a critical yet risky mission sets potentially carried out under extremely harsh operating conditions.

As the demands get closer to personal limits, it becomes more important to optimize human performance and track real time the physiological status of the operator on the ground. PSM has many benefits including Command and Control (C2), Tactical Combat Casualty Care (TCCC), and Human performance (HP) and the beauty is that a single solution can serve all three purposes simply by changing the radio communications and display device.

In training PSM can enhance human performance training effectiveness and increase operation risk management and awareness. PSM decision thresholds can be tuned on an individual level, based on the individual's performance metrics enabling intelligent alerting. Wearables can be worn as a patch, strap, in a mouth guard or on a shirt and can be non-visible to the enemy and non-combatants alike.

The position of the sensor on the body is vital to record an accurate portrayal of the body's movements, while tracking the most important vital signs, including actual physical death. PSM can be a critical data source in a mission that when used real time can be a game changer in the field. In this article we will give a brief explanation of the sensors, transmission and graphical displays that make a wearable sensor solution useful in the field.



Tactical Display Software PC and Android

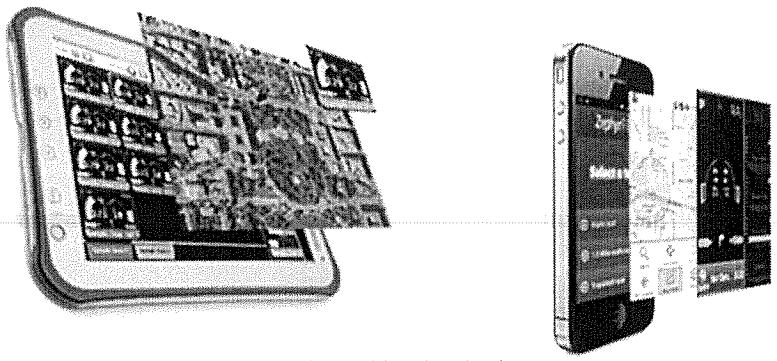
Signals on the Body



We are entering a time in which wearable technology requires devices that are small enough to be comfortable and undetectable with the capability to be wirelessly connected, and have algorithms serving societal needs in healthcare, fitness, and operations. Previous barriers are no longer in existence such as processing power, battery technology, radio bandwidth and display technology. The various challenges that once posed issues have been overcome. PSM sensor data includes Electrocardiogram (ECG), heart rate, respiration rate, heart rate variability, core temperature, posture and activity, emotional stress monitoring, heat stress detection and dehydration, physiological load. All of these parameters can be used to assess a

teams mission capability. ECG and other vitals can now be measured on bodies that are in motion. Equipment is visibly undetectable and can be incorporated into existing uniforms ready for deployment.

Display Technology



Tactical Display Software PC and Android

Display resolution and daylight viewing has improved dramatically in recent years driven by smart phones, computers and watches. Additionally, the development of operating systems for these devices that support simple applications make it possible to have remote access to anything that can get to a cloud virtually anywhere. Displaying data to a user or decision-maker while technically easier still requires information to be presented in a useful and intuitive way without requiring the constant attention of a technical or medical expert. Remote users, clinicians and commanders require sensor display fusion such as Google Maps or FalconView. Event-based alerting based on high sample rate localized analyzed enables powerful exception based reporting with commanders dealing with vital sign summaries on a as needed basis.

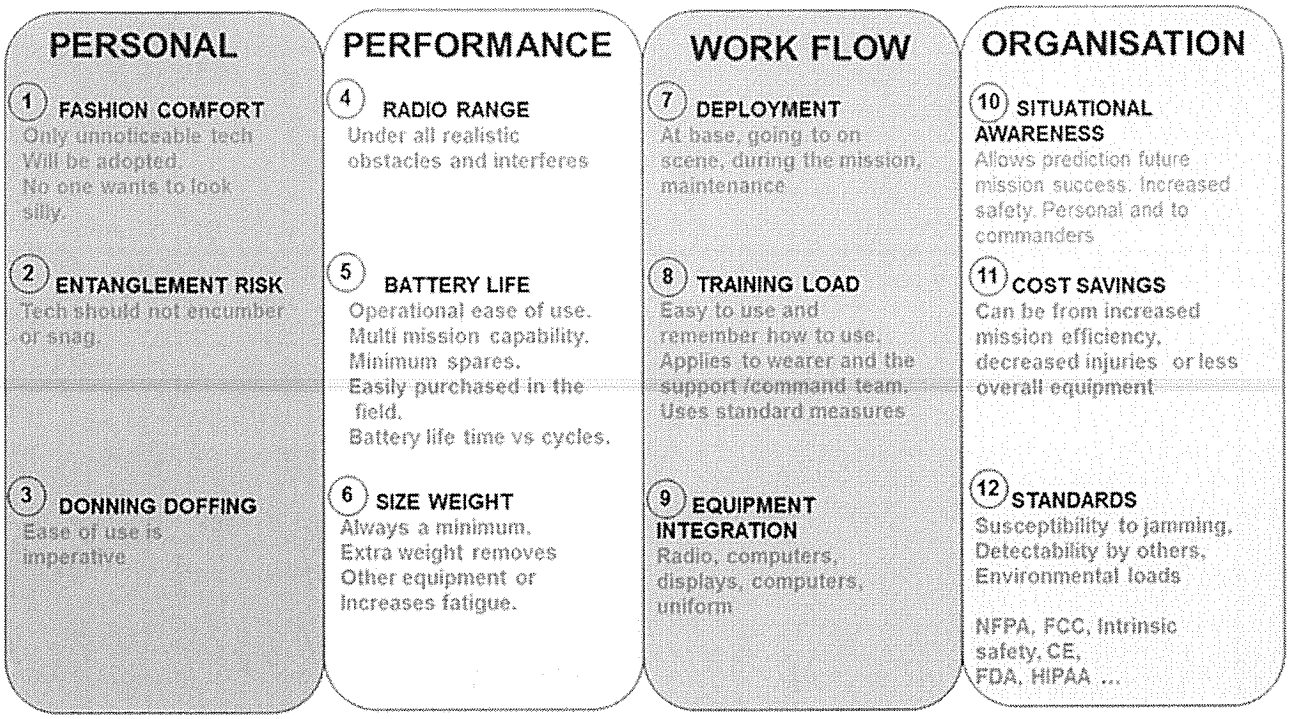
Personal display devices worn by the operator allow users themselves to be self-aware, so that they better understand their own limitations in terms of heat stress, dehydration, fatigue, and mission strain both in training and operationally.

Initial Applications

Researchers in physiology and psychophysiology were first movers with wearable sensors. Key problems were being solved such as, "is the astronaut alive?" and pilot fatigue,. Organizations such as NASA have used wearable's on projects, for example, using Zephyr's BioHarness, on MARS mission simulation, zero gravity cardiac research and commercial flight crew research. Early adoption required hours of human analysis which is now performed in minutes with analysis software. In 2005, US Special Forces competitively bid for remote vital sign monitoring seeing the value for C2, TCCC + human performance and identifying the gap in uniform, radio communications and C2 software integration. This contract resulted in vital sign monitoring sensors designed to complement the warfighters tasks and uniform e.g. Ballistic plates, tactical radio integration with secure body area networks and software integration with command and control software such as Falcon View. Development resulted in automated triage algorithms and bulk fitness assessment to automate personalized thresholds. In 2010 the 33 Chilean miners wore the Zephyr BioHarness for 6 weeks while trapped 2000 feet underground and as the world watched to see if they would be rescued. Today SWAT, WMD Responders, Hospital Patients and chronically ill consumers at home use the same sensor package, worn in different methods so they can stay healthy and can carry out successful missions or live safer more productive lives.

Design Flow

When designing a wearable sensor various tradeoffs are required.

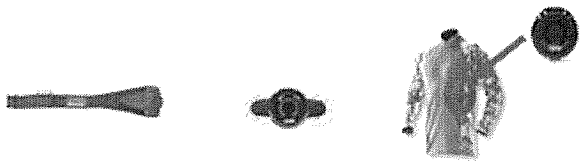


Size, weight and volume is the number one driver for all wearable's. With today's technology weight and volume is typically below any threshold that matters to the user. However size is always a concern.

Battery technology is typically 40% the volume of a wearable sensor. The drivers for battery capacity are several;
Sensor measuring on time – should the sensor continuously monitor or wake up on events?
Processing power – should the sensor provide raw data or supply interpreted actionable information.

It has been our experience that more processing locally allows high resolution high sample rate data to be used algorithms for intelligent assessment and calculations of an individual's readiness status. This approach leads to less data being transmitted saving radio bandwidth and battery power. In most circumstances the devices can only transmit on significant events rather than continuously, thus saving power for the long range radio or cellular phone.

Human Performance



Wearables allow for groups of individuals to have a group fitness assessment and track individuals in their conditioning programs. Coaches and trainers have learned to take advantage of the data collected in order to develop optimized conditioning programs factoring nutritional needs (caloric expenditure), physiological, and mechanical demands and loads on the body. Additionally, wearable's can be used to measure mental performance during an exercise which can be useful in training to ensure proficiency has reached the point of "muscle memory" versus when the wearer is still emotionally and mentally strained, even if not physically strained.

Civilian Medical Applications

Wearables have applications in the civilian world through a broad spectrum of medical applications in preventative medicine, remote telemedicine, and outpatient care environments. A recent National Institute of Health study was conducted with Chronic Heart Failure patients in their homes in one of the most remote regions of the Arizona desert in the United States. Patients were able to receive care in their homes, reducing highly straining trips to the hospital for checkups, enabling them to spend more time with their families in a comfortable and caring environment.

Conclusion

Wearables are often misunderstood as being a thing of the future, but the truth is the future is here. There are already existing solutions available at consumer of the shelf level pricing.

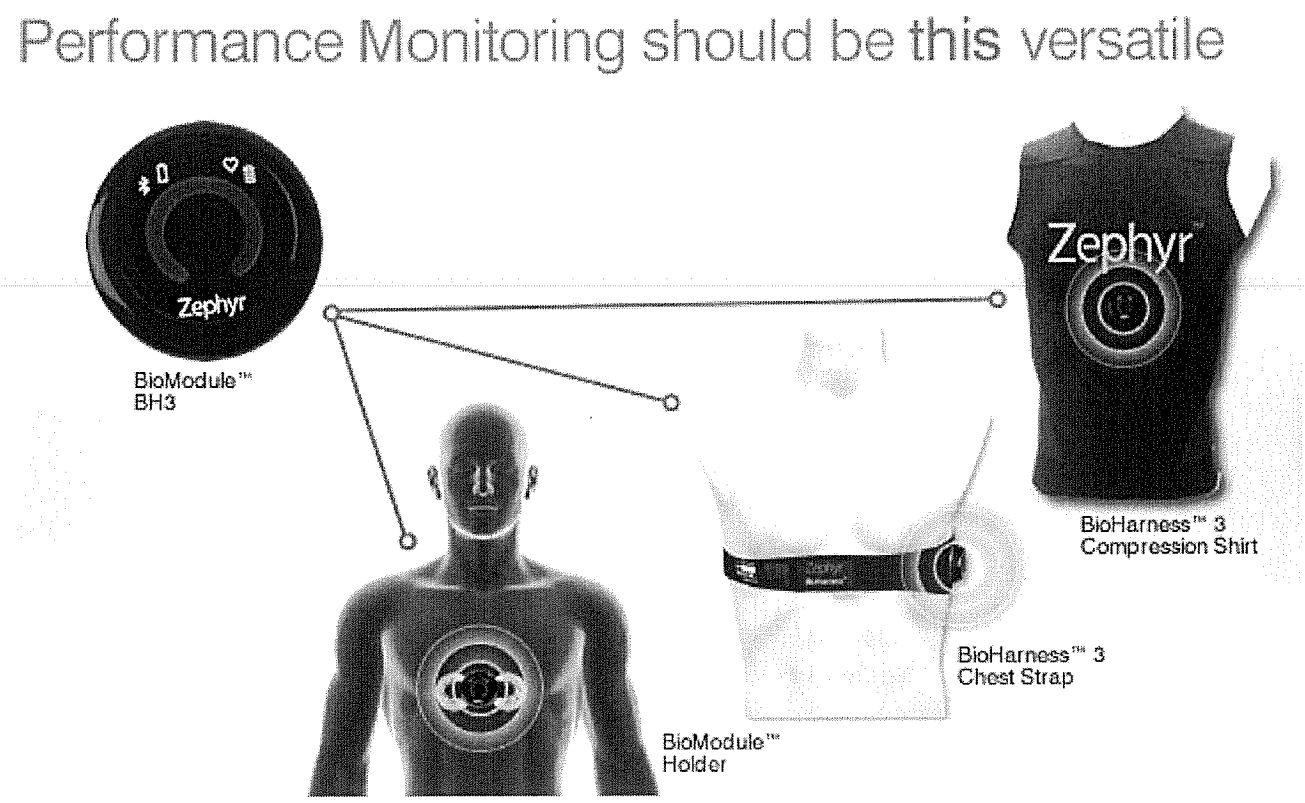
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Designed To Make Montioring Wireless

The BioHarness™ 3 is the premiere compact physiological monitoring module that enables the capture and transmission of comprehensive physiological data on the wearer via mobile and fixed data networks – enabling genuine remote monitoring of human performance and condition in the real world.

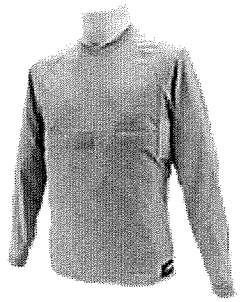
BioHarness™ 3 has applications in any field requiring high-level wireless and remote physiological monitoring, including research, training and wellness situations. It offers a vital advantage to users in a diverse range of sectors, including academic and research, sports, defense and wellness.



BioHarness™ 3 Compression Shirt

Compression Shirts & GPS

By simply attaching the BioModule to the front of the Compression Shirt, and inserting a GPS module into a convenient pocket on the upper back, athletes can easily measure and monitor both physiology and Accelerometry. Meeting all Zephyr's rigorous wash and wear standards, the compression shirt feels great and adds to a sense of performance. Available now in the Zephyr Store


Military & Responder Loose-Fit Shirt

Loose-Fit Shirts for First Responders and Defense Applications

Designed specifically for the BioHarness 3, Zephyr offers a variety of garments that allow wearable monitoring in a variety of environments and situations. When you need to monitor your team's health remotely while on the job on a daily basis, you need apparel that will not only perform up to your rigourous needs, but that your team also wants to wear every day. Our loose-fit shirts deliver high-quality performance and durability while remaining comfortable and machine-washable.


Loose-Fit T-Shirt

The Proof is in our Experience

- Read how Stanford University uses Zephyr's PSM System
- See How BioHarness Kept the Chilean Miners Safe
- The BioHarness and Extreme Sports

Features*

- Uses Bluetooth to provide heart rate, RR Interval, speed & distance to your Android devices
- Machine Washable strap that offers both comfort and accuracy
- Long transmission range (~300ft up to ~1000ft)
- Water Resistant up to 1m
- Logs and stores up to 20 days of data
- Available GPS module provides speed, distance and location

Specifications

HR Range:	25 – 240 BPM
BR Range:	4-70 BPM
Acc. Range:	±16g
Battery Type:	Rechargeable Lithium Polymer
Battery Life:	26 Hours per charge
Charge Cycles:	300

Measurements

- Heart Rate
- R-R Interval
- Breathing Rate
- Posture
- Activity Level
- Peak Acceleration
- Speed & Distance
- GPS

Transmit Range:	To ~300ft, ~1000ft w/Antenna & Amplifier
Frequency:	2.4 – 2.4835GHz
Garment Washes:	80
Operating Limits:	
Temperature:	-10 – 60°C
Humidity:	5 – 95%

For Developers

Visit ZephyrLABS to get the latest tools

Solution Comparison Guide

	ZephyrLIFE™ HOME	ZephyrLIFE™ HOSPITAL	PSM Training	PSM Responder	PSM Defense
	Learn More	Learn More	Learn More	Learn More	Learn More
BioPatch™	X	X			
BioHarness™ 3			X	X	X
FDA Class II (Rx Only)	X	X			
Chest Strap	X	X	X	X	X
BioModule™ Holder	X	X	X	X	X
Compression Shirts			X	X	X
Loose-Fit Shirts			X	X	X
Bluetooth	X		X	X	X

ECHO Mesh Radio		X	X	X	X
2Net Connectivity	X				
HealthHub™ Connectivity	X				