This presentation rated R for REALLY IMPORTANT
# Real-time Monitoring of our Warfighters Health State: The Good, The Bad, and The Ugly

## Abstract


## Subject Terms

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Real-time Monitoring of our Warfighters Health State:

Presented by
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at ATA 2008
Seattle, WA

This presentation rated R for REALLY IMPORTANT
Disclaimer

- The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or reflecting the views of the Army or the Department of Defense.
The idea of monitoring a Warfighter’s health state is not new.

Circa 1956

Circa 1959
Situational awareness is limited to the immediate presence of a medic.

No tool to monitor individual/unit health readiness or triage casualties at a distance.

No remote awareness of casualty vital signs.
- Medics attending to Soldiers KIA
  - endangers medics
  - limits resources

Background: Why real-time monitoring?
Background: Why real-time monitoring?

- Thermal casualties
  - reduce unit readiness
  - can be fatal

- Dehydration
  - $\uparrow$ risk thermal casualty
  - $\downarrow$ physical & cognitive performance

- Limited Sleep
  - $\downarrow$ cognitive performance
  - $\uparrow$ preventable accidents
Paramount Considerations

- Minimal Power, Weight, and Cube
- Open Architecture to Facilitate Upgrades
- Block/Spiral Development
- Keep it Small and Simple
- Minimize Logistics Trail
- Economically Reproducible
Decision Assist Tool Complexity

- No medic eyes on
- Hard to test Vital Sign Algorithms
- False positives must be very low
  - i.e. Don’t say someone is dead when they are alive and can be helped
- Human device interface is complex
- Artifact

Hardware
- Is it connected?
- How is the battery?
- Did is slip?
- Proper tension?
- Was it shot off?
- Was it properly put on?

Activity
- Movement / placement
- Talking
- Vehicle movement
- Gun fire
- Run with load
- Pack shifting

Goop & Goo
- Grease / Camouflage
- Repellents (DEET, promethryn)
- Sugars
- Washing / Cleaning
  - Chlorine
  - Detergent
The GOOD Technologies & a solution framework have been greatly advanced. Health state monitoring is no longer science fiction.

Maturing Sensors
WPSM Design Principles
WPSM Design Framework
Certification and Lab Testing
Medical Monitoring
Maturing Sensors

- **Sensor Development**
  - **Foster Miller**
    - Added ECG and Respiration Waveform Capabilities
  - **Hidalgo System**
    - Added Core Temperature Capabilities
  - **Quasar**
    - Fielding a initial system to Aberdeen Test Center (Jan/Feb 2008)
  - **Zephyr**
    - Commercially available system with ECG and Resp. Waveform

- Foster Miller
- Hidalgo Equivital
- Quasar
- Zephyr
- Vivometrics Lifeshirt 300S
Real-Time Monitoring Design Principles

- Modular
- Open
- Extensible
- Personalizable
- Spiral Development
- Initial Capability (IC) “Locked”
**Current**

**Sensors**
- VSDS
- BIDS
- FIM
- Core Pill
- Temp Patch

**Network**
- Hardwire
- Mini Mitter Vital Sense Network
- Blue Tooth (FFW)

**Info. Management**
- HEALTH HUB
- State Classifiers: Vital signs, Thermal, Hydration Sleep Performance Models

**Customers**
- Land Warrior
- Future Force Warrior

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**Future**

**P3I**
- Non-Contact ECG
  - Cardiac Output
  - Non Invasive Core Temp.
  - Cardiac Output
- Inductive
  - Zigbee
  - Stealthy
  - Through Body
  - Ultra-wide Band
- Movement Classifiers
  - Metabolic Rate
  - Individual Models
  - BIDS Wound Location
  - BIDS Wound Severity
  - Triage
- Early Insertion Efforts
  - SOF
  - Rangers
  - CST-WMD
  - Training Units
Real-Time Monitoring: Initial Capability System

BMIS-T
Medic Display

Hub
911 Button
Runs Health state algorithms
Interfaces with the PIC/EIC

Vital Sign Detection System (VSDS)
ECG, Respiration, Ambulation, Body Orientation, Skin Temp.

Core Temp
Thermal State

Fluid Intake Monitor
Hydration State

Sleep Watch
Cognitive/sleep Performance State

Real-Time Monitoring:
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Certification and Lab Testing

- **FDA 510K Certified (November 2006):**
  - Heart Rate Monitor
  - Respiration Effort Monitor
  - Welfare Index

- **Lab Validation Testing**
  - February 2006
    - HR +/- 2 bpm
    - RR +/- 3 bpm (for low activity)

- **Human Factors Testing**
  - 2004 early form factor testing
    - Devices worn during field exercises for 8 hours – 72 Hours
    - Iterative design process to fix comfort and durability issues
1st CST-WMD Real-Time Medical Monitoring Methods

1st CST-WMD Enclosed Space Training Event (June 7 & 8, 2007)
- 2 Day Event
- Monitor Environment
- Monitor Physiology
- Display Physiology in Real Time for Use by Physician Assistant

The GOOD
**Medical Monitoring**  
**Telemetry System – In Action**  
**Results – Physiology, Real Time Display**

### CST Medical Telemetry Monitor

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#### 1st CST - WMD Medical Telemetry Monitor

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**OK | Current Time: 11:24:35**
The BAD

Unique challenges make the creation and fielding of a product difficult.

Changing Objectives
Changing Requirements
Changing Configurations
Changing Objectives

- **2004 Comprehensive Physiological Status Monitoring System – Integrated into Objective Force Warrior (OFW)**
  - Thermal State, Hydration State, Cognitive State, Vital Sign State, Ballistic Impact Detection
    - Technology Down Select
    - Human Factors form fit design to meet OFW ensemble
    - Integrated algorithms and network

- **2005 Stand Alone WPSM system for Future Force Warrior (FFW)**
  - Intellectual Property and Funding Issue to Integrate Network
  - FDA Issue to integrate algorithms
  - Hydration State requirement dropped

- **2006 Stand Alone Vital Sign Detection System (VSDS)**
  - Change from WPSM network to standard Bluetooth Network
  - Change to new interface specifications

- **2007 FFW Program Ends - Now Integrate to Land Warrior**
  - Hardwired interface required because of security issues on the battlefield
  - Only leaders will have radio systems

Two original ATO’s schedules were synchronized.
The FFW ATO was extended but the WPSM ATO was not.
Thus WPSM and FFW schedules became out of sync.
VSDS was originally specified with an integrated Ballistic Impact Detection Technology

- Final specification was simplified
- Only Vital Signs Detection was wanted/affordable

The communication link for health status information was planned as the individual radio

- Land Warrior: current decision is to have radio only on the team leaders
### Initial Design
- Multiple sensors
- Wireless sensor network
- No Soldier computer
- No Soldier radio
- No body armor
- PDA display

### Future Force Warrior (FFW) Design
- One sensor
- Bluetooth wireless sensor connection
- Soldier computer
- Soldier radio
- Integrated load carriage and body armor with standoff
- Front chest sensor location

### Land Warrior (LW) Design
- One sensor
- Wired sensor connection
- Soldier computer and radio only on leaders
- Interceptor body armor with no standoff
- Side sensor location
The UGLY

The DOD acquisition process is complex. Redirecting early component work to enable a good fieldable system requires time, effort, and coordination.

Deliberate Capabilities
Development process
FFW System of Systems
FFW “System of Systems” (SOS)
The Deliberate Capabilities Development Process (JCIDS)
Despite current challenges of fielding integrated solutions the future is very bright.

Significant advances in technologies and supporting firmware/software will continue to be made.

Academia, industry and the Defense Department will share in the further development and exploration of these technologies.

The potential of future applications to home health care, safety monitoring, professional & recreational athletes, research and the Department of Defense are tremendously exciting.
Summary

- Lab on a chip
- The individual “dashboard”
- Personalized medicine
- Remote “office calls”
- Affordable, integrated solutions
- Performance optimization based on individual’s physiology
- Previously unattainable real-time data sets.
50 years ago Starship Troopers was written as science fiction

What of today’s science fiction will be possible in 2059?
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