Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

10th Annual Cyber Therapy 2005 Conference
together with
The **1st International Conference on Applied Technologies in Medicine and Neuroscience**

10 June 2005

COL Beau J. Freund, Ph.D.

Deputy Commander, US Army Research Institute of Environmental Medicine

Program Manager, WPSM IC STO

beau.freund@na.amedd.army.mil
508-233-4811

Presentation Overview

1. Why WPSM-IC
2. STO Objectives
3. System Components / Architecture
4. Data to Information Process
5. Possible Input for Adaptive Displays
6. How it might look (COP/CROP)
7. Challenges to Implementing Solutions
8. WPSM IC Team/Partners

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

"Why" WPSM-IC?

- In the Army's future "battle space" area of operations, soldiers will be more dispersed (including medics)

- This dispersion will likely degrade current medical capability and increase morbidity and mortality

- WPSM-IC will provide **remote** situational awareness allowing the warfighter to maintain readiness through preventive health interventions

- WPSM-IC will enable the medic to direct his resources to the casualties that will most benefit.

- WPSM-IC will provide information to Commanders and/or Operations and Logistics Officers useful in Planning and Risk Assessment.

Objectives

- Generate operationally relevant *performance and health status indicators* for use by commanders and medical personnel
- Provide a warfighter acceptable*, wear and forget, physiological monitor* for use in both training and military operations
- *Maximize warfighter operational effectiveness and prevent casualties* by integrating predictive modeling with real-time physiological monitoring
- *Detect ballistic wounding*, and provide vital sign status for remote triage when integrated with a digital medic capability, and determine health status.

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

Medical Information / Communication Hub

- Austere low power personal area medical network
- Models & algorithms for: life signs, thermal, hydration & cognitive states.
- Soldier 911 Button
- Personal/Electronic Information Carrier (E/PIC) enabled
- Interface to: Future Force Warrior (FFW), Battlefield Medical Information System-Tactical (BMIS-T)

Hydration State

Measures fluid consumption through a bladder style canteen. Can estimate hydration status by knowing work rate, environment and uniform.

Thermal State

Measures core temp. from ingestible pill. Warns of impending thermal casualty. Mission / Medic Indicated.

Sleep/Cognitive State

Measures sleep as a consumable quantity which needs replenishment Equates sleep to cognitive readiness. Will assign risk to individuals and activities.

Life Sign Determination

Integrated system with multiple parameters and algorithms (Life Signs, HR, RR, Body Orientation, Activity)

Ballistic Impact Detection

Alerts when on body acoustic signals indicate a ballistic projectile has impacted the Warfighter

Science and Engineering Basis

Science Engineering

- WPSM has both a scientific basis and an engineering component. Both are needed for a successful product.
- Science provides the knowledge of which parameters need to be measured.
- Engineering provides the hardware tools to measure the appropriate parameters in harsh ambulatory settings
- In WPSM there are many trades between ideal physiologic parameters and the technology available to measure these parameters on a soldier

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

Yesterday - Behind The Scenes

Army Science Conference 2002

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

Today – Integrated Hardware

Fluid Intake

BMIS-T

Cognitive State (Sleep History)

PIC Card

Life Sign Detection

Thermal

Medical Hub

911 Button

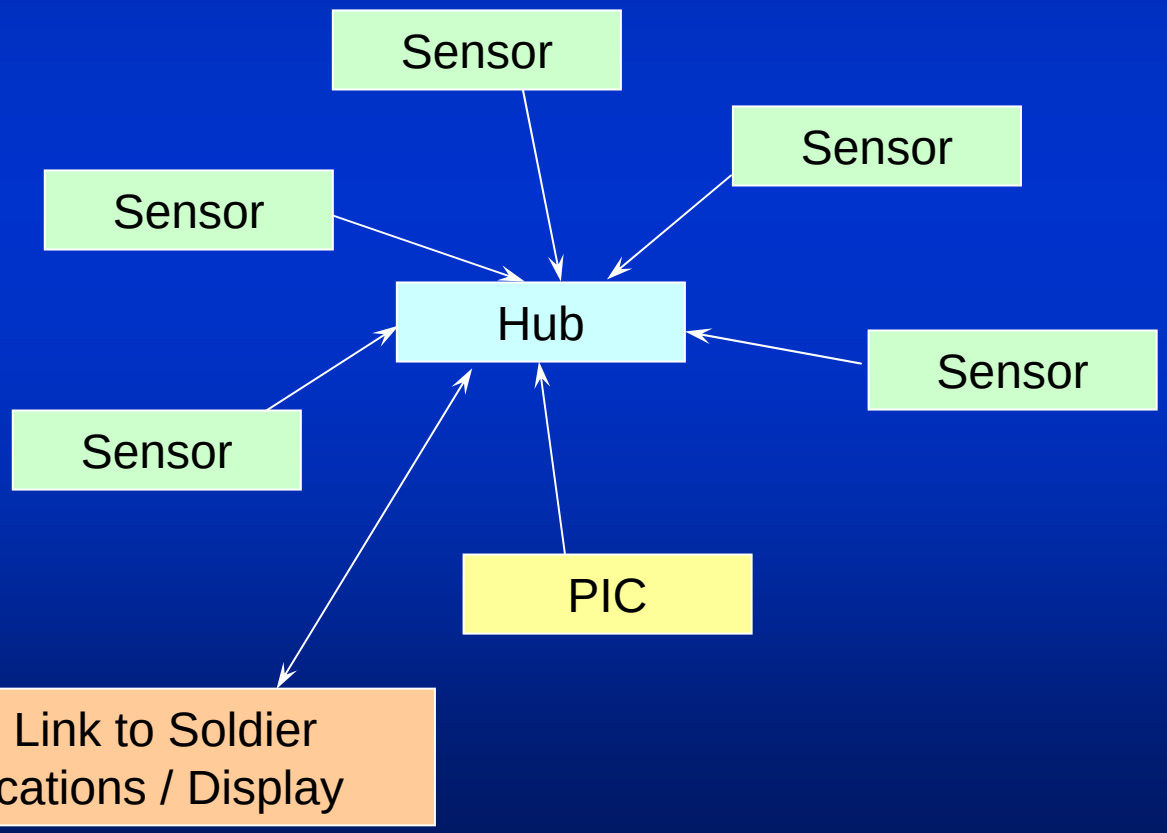
BIDS

Paramount Considerations

- Soldier Acceptability, Ease of Use, and Value
- Minimal Power, Weight, and Cube
- Open Architecture to Facilitate Upgrades
- Block/Spiral Development
- Keep it Small and Simple
- Minimize Logistics Trail
- Economically Reproducible in Mass

Network Requirements

- Minimal Data Loss
- Known Data Loss
- Low Power
- Low Bandwidth
- Withstand Cross Talk



Data to Information Process

- The WPSM system provides REMOTE physiologic and medical state information about a warfighter.

Signal Integrity	***Precision Error***	***Confidence Window***	***Probability***	***Assurance***	
On Body Sensors (Data)	**Feature Extraction**	**Multi Signal Fusion**	**Classifier Models**	**Machine Inference**	**Information**
•Site & Signal Availability •Artifact & Sensor Characterization	•Noise Filtering •Feature Reconstruction	•Smart Algorithms •Arbitration	•Generative classification •Gausian •Hidden Markov	•Rules (if, then) •Basian •Heuristics	•System Based •Informatics •FDA

What Kind of Information

- For each of the WPSM information areas we provide four states:
  - **RED** "Look Now"
  - **YELLOW** "Look"
  - **GREEN** "OK"
  - **BLUE** Unknown/System Fault
  - Along with the state classification is a statistical confidence
- Unprocessed data/wave forms are not sent to medics.

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

Future Effort

Operational / Medical Situational Awareness for Commanders and Medics

Adaptive Models
- "Learn" Individual "Normal"
- Adaptive Information Display

Better Sensor Fusion
- Electro Textiles
- Stealth Wireless Network

Enhanced Remote Triage
- Injury Severity
- Cognitive Assessment
- Priority of Care
- Priority of Evacuation

Enhanced Technologies
- Pulse Oximetry
- Cardiac Output
- Blood Pressure
- Lab on a Chip
- Neurological Assessment

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

Inputs for Adaptive Displays (An example)

Physiological Factors

Parameter	"Sensor"
HR	R-wave Detector
RR	
Metabolic Status	Pedometry/Actigraphy/GPS
Hydration Status	
R-R Interval	Digital ECG
Body Posture/Position	Accelerometry
Thermal State	Skin and Core Temperature
Blood Pressure	Pulse Transit Time

"Psycho-Physiological" Factors

Parameter	"Sensor"
Emotional Status	Voice Stress
Sleep Status	Sleep Actigraphy
Fatigue	Percent Eyes Open - Papillary Reaction
Vigilance	EEG
Motivation	Cerebral Blood Flow

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)

Inputs for Adaptive Displays (An example)

Duty Position

- Rifleman
- Forward Observer
- UAV NCO
- Medic
- Commander

Pre "Loaded"

Activity Factors

- Road March
- Convey Ops - Entry contact likely/unlikely
- Movement to Contact
- Assault

Sensor / User Selected

Individual Factors

- Personality Type
- Naive vs. "Seasoned" Soldier
- Resilient
- "Emotional"

Pre "Loaded"

Other Features

- In Vehicle
- High Noise
- Day/Night
- Environmental (e.g. altitude)

Sensor

Possible Process

Feature Extraction – Data Fusion	Classify (Stress)
Physiological Factors Sum { 1 to N factors }	High Medium Low
"Psycho-Physiological" Factors Sum { 1 to N factors }	High Medium Low
Duty Position/Acting Factors Sum { 1 to N factors }	High Medium Low
Other Factors Sum { 1 to N factors }	High Medium Low

Inference

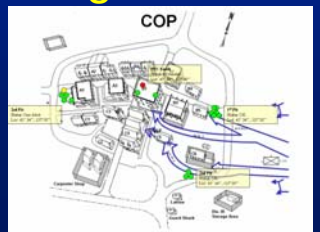
Rules:
Basian, Heuristics, etc.

Rules to "drive" adapter display

Drive

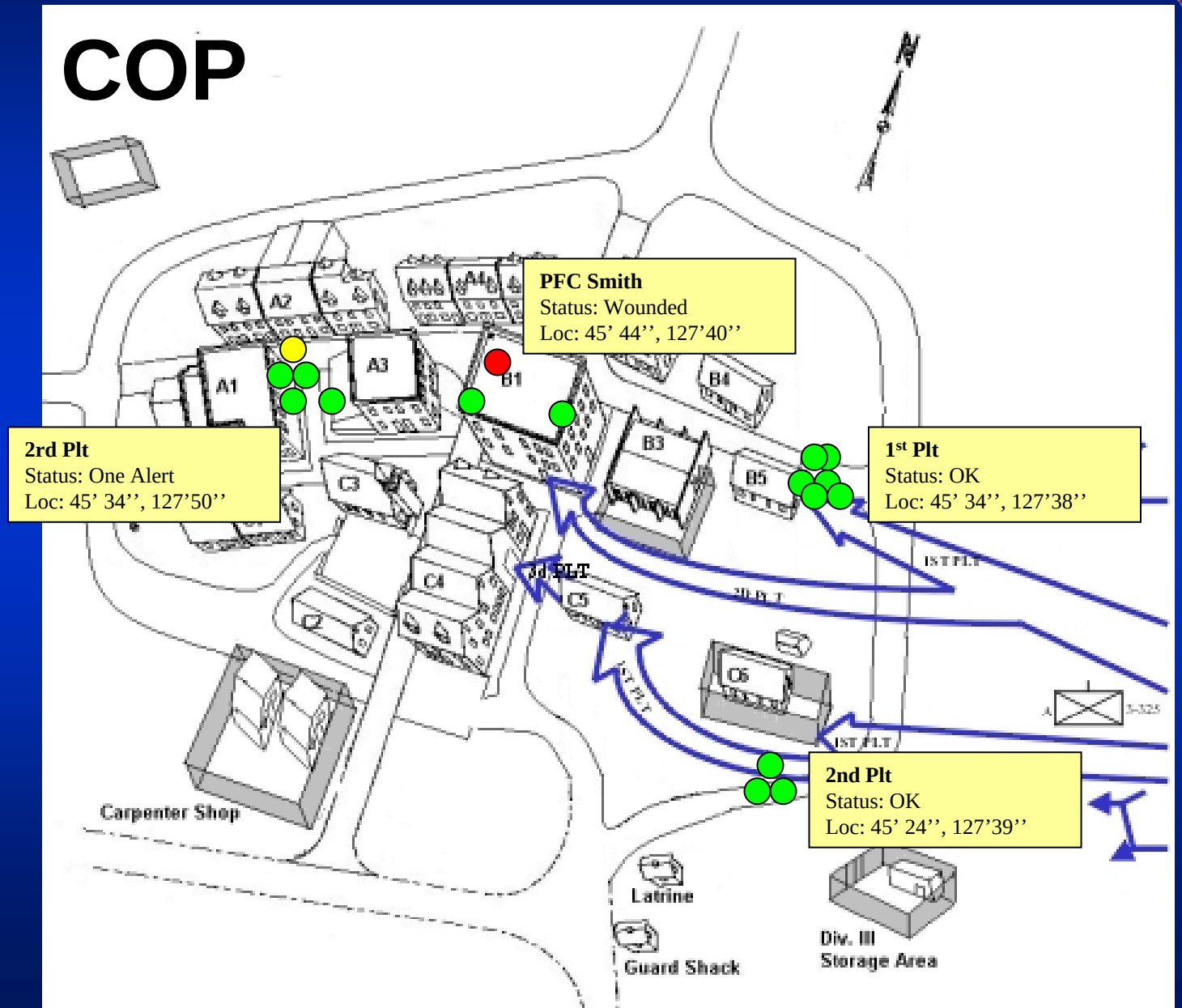
Display Selection

High Stress

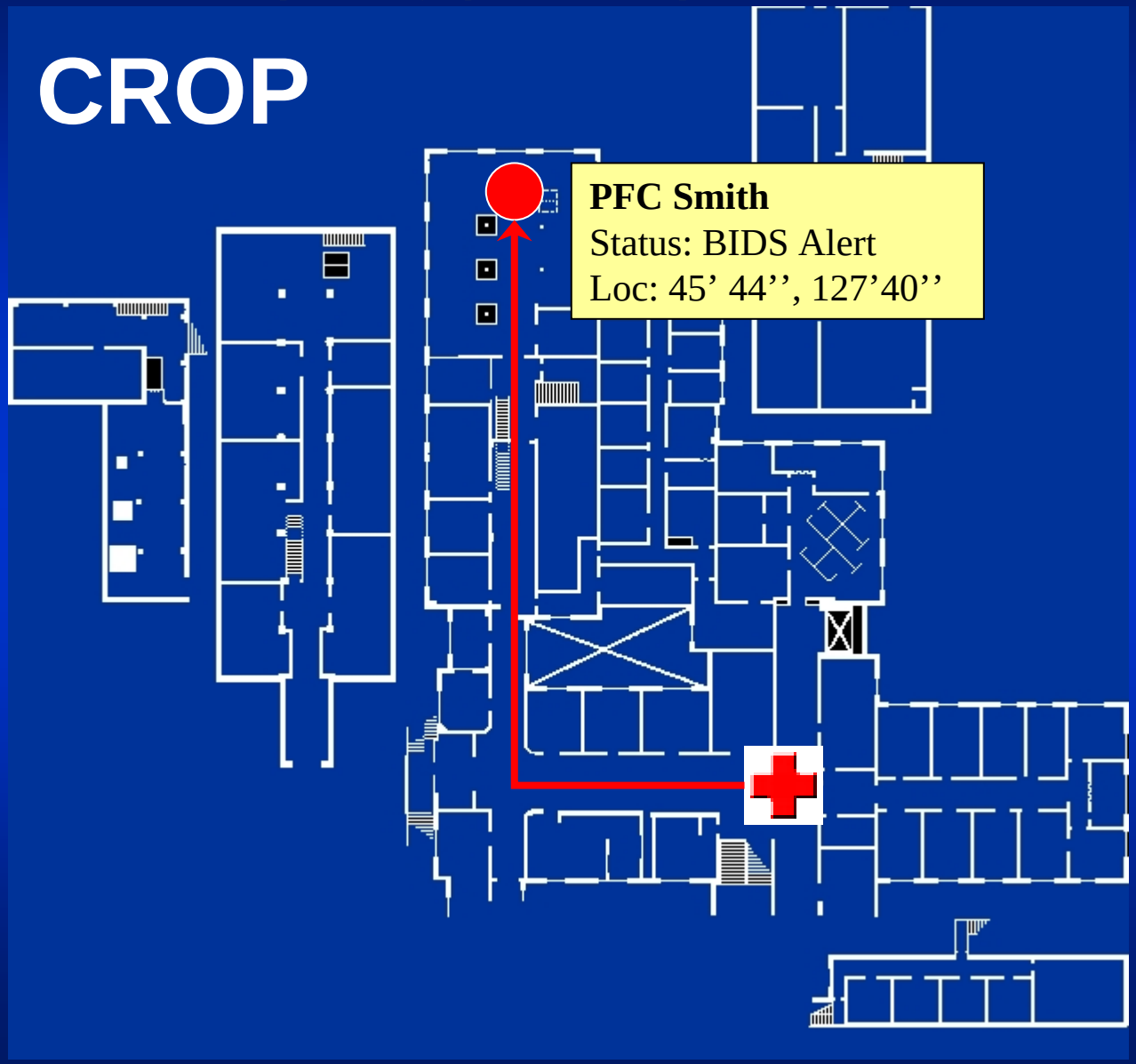


Low Stress

Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)



Warfighter Physiological Status Monitoring - Initial Capability (WPSM IC)



Challenges to Implementing Solutions

1. User/Warfighter acceptability.
2. Integration of multiple sensor inputs (sensor priority, redundancy, synchronization, data freshness).
3. Probabilistic vs. Individualistic – Models/Algorithms.
4. Information needs “context”.
5. Do we know enough to identify an abnormal/inappropriate psycho-physiological response.
6. Can the models “adapt”.
7. How do we validate (i.e., is simulation adequate?).

Partners

- Medical Research and Materiel Command
  - USARIEM
  - WRAIR
  - TATRC
  - USAISR
- Future Force Warrior Program Office
- Natick Soldier Center
- AMEDD Center & School
- Warfighter Community
- PM-PEO Soldier Equipment
- CECOM
- Foster Miller
- Hidalgo
- Odic
- Mini Mitter Inc.
- Sarcos
- Vivometrics
- Design Turn / Medicept
- Dartmouth College
- MIT- Media Laboratory
- CIMIT - Life sign detection
- Brown University
- Precision Control Design, Inc.
- Aware