Performance Sustainment and Health Protection in Operational Environments

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20 April 2016

Panel Members

- **LCDR Christopher Steele** – Science & Technology, Deputy Director, MOMRP
- **Mr. Clifford Otte** – Senior Technologist, USAFSAM, 711th Human Performance Wing
- **Dr. Andrew Midzak**– MOMRP Physiological Health Portfolio Manager
- **Dr. Richard Shoge** – MOMRP Injury Prevention Portfolio Manager
- **Dr. Ryan Mayes** – USAFSAM, 711th Human Performance Wing
- **Ms. Maureen Milano** – Advanced Development, Medical Support Systems, US Army Medical Materiel Development Activity

Environmental Health and Protection Portfolio

Dr. Andrew Midzak

Military Operational Medicine Research Program

US Army Medical Research and Materiel Command

20 April 2016

Environmental Health & Protection Problems

- Maintaining warfighter readiness is responsibility of small units leaders.
- Mitigation strategies for the combined impact of heat, humidity, altitude and/or cold stressors.
- Technologies needed for optimal hydration status management
- Nutrition solutions to optimize recovery
- Biomarkers of exposure to toxicant environmental health hazards.

Maintaining warfighter readiness is responsibility of small units leaders

- Non-invasive sensors (low size, weight, and power) for real-time physiological and cognitive status monitoring that are open architecture
- Robust biomarker sensors for harsh conditions such as those in military environments
- Data derived from commercial sensors that is reliable, accurate and actionable

Medical Problem and Gaps in Technology

Mitigation strategies for the combined impact of heat, humidity, altitude and cold stressors

- Technologies for optimal cooling management in hot weather training and operations.
- Technologies for focused heating solutions for mitigating the risk of non-freezing injury in cold weather training and operations.

Medical Problem and Gaps in Technology

Technologies needed for optimal hydration status management in training & operations

- Non-invasive methods for detection of dehydration.
- Wearable autonomous hydration status monitoring.

Nutrition solutions to optimize recovery following high optempo operations

- Nutrition countermeasures for recovery from physical and cognitive degradation during military operations.
- Protection strategies to mitigate operational stress.

Biomarkers of exposure to toxicant environmental health hazards

- Biomarker panels for exposure to industrial chemical mixtures found in dense urban environments.
- Accurate dose information for exposure to industrial chemical mixtures and material hazards.
- Adverse health outcomes linked to biomarkers of toxicant exposures.

Injury Prevention and Performance

Dr. Richard Shoge
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20 April 2016

Purpose

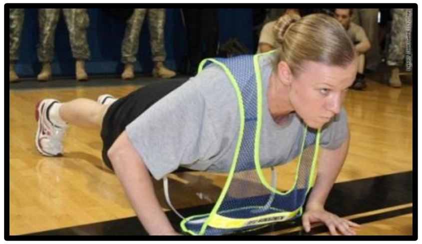
To reduce musculoskeletal injury (MSI) rates and optimize performance and readiness across MOS

- Musculoskeletal injuries are the number one medical problem eroding military readiness
  - ➢ MSI were the leading cause for all medical encounters (1.95 million) in 2006 for all of the US military.
    - 2–3 times greater than the next leading category (mental disorders)
  - ➢ In 2010, the AFHSC reported that MSIs of deployed and nondeployed service members were responsible for the greatest number of medical encounters (30%)
    - The next leading cause of medical encounters (15%), were mental disorders.

- Physical training and fitness are required to accomplish military missions
  - Bell et al. (2000) reported that 27% of men and 57% of women experienced >1 injuries during BCT.
  - Knapik et al. (2009) reported an injury incidence rate of 0.56 and 1.16/100 person days for men and women respectively, completing BCT.
- "Coordinated, well-planned, and multifaceted approaches to training and optimizing performance should be based on an understanding of the many factors involved will have a positive impact on reducing the levels of injuries."

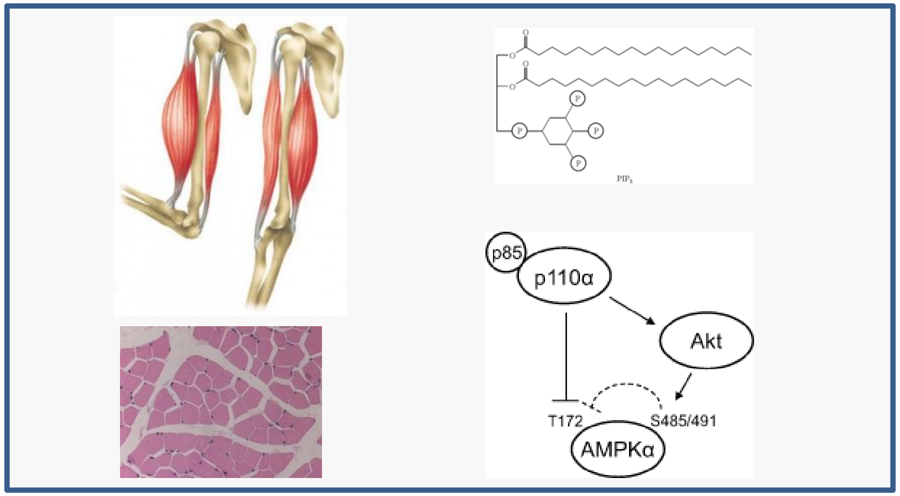
MOMRP S&T MSI Programs

- Army Program
  - Physiological Mechanisms of MSI
  - Return to Duty Standards and Strategies
- Defense Health Program
  - Injury Prevention Strategies in Training and Operational Environment
  - Women in Combat

Physiological Mechanisms of MSI

- Better understanding of the physiological mechanisms underlying musculoskeletal injuries.
- Countermeasures to mitigate injury risk potential will be identified for exploitation in Army training doctrine.



Return to Duty Standards

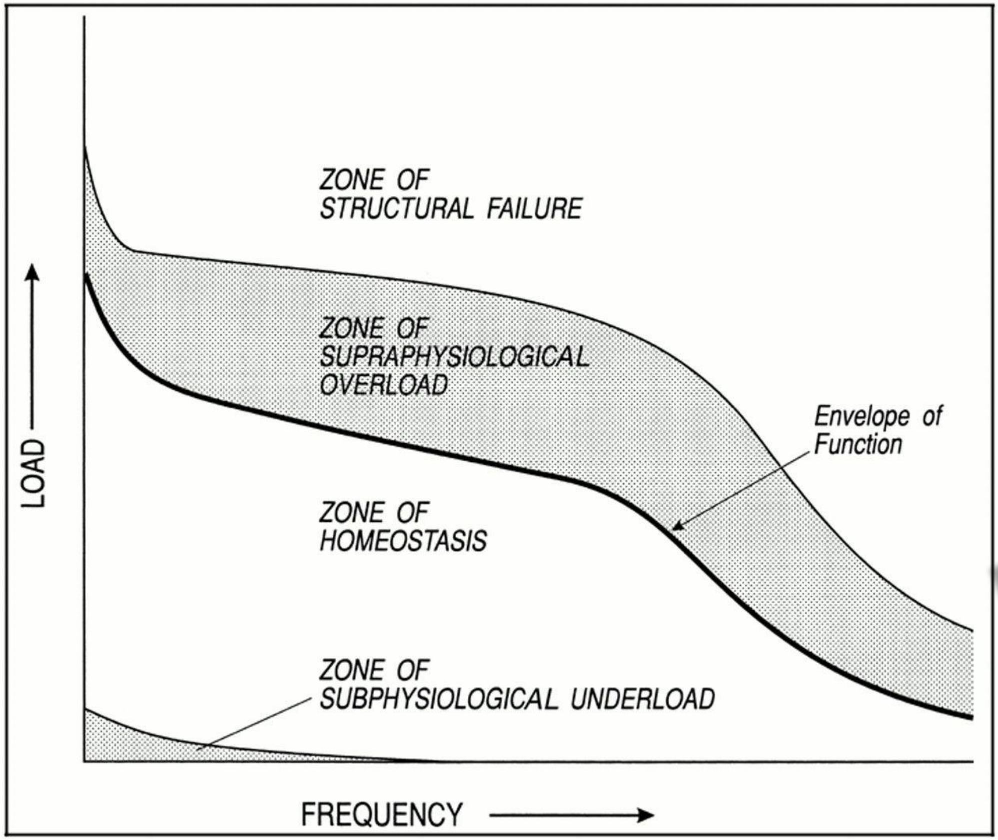
- Standards and criteria are essential to identify when Warfighters are capable to Return-to-Duty (RTD), fully able to perform demanding tasks.
- Major gap:
  1. Occupation-specific abilities (e.g., manual tasks, locomotion, physical combat, marksmanship)
  2. Prevention of disability related to musculoskeletal injury

Prevention Strategies in the Training and Operational Environment

“Envelope of Function”

MOS Tasks:
Lifting

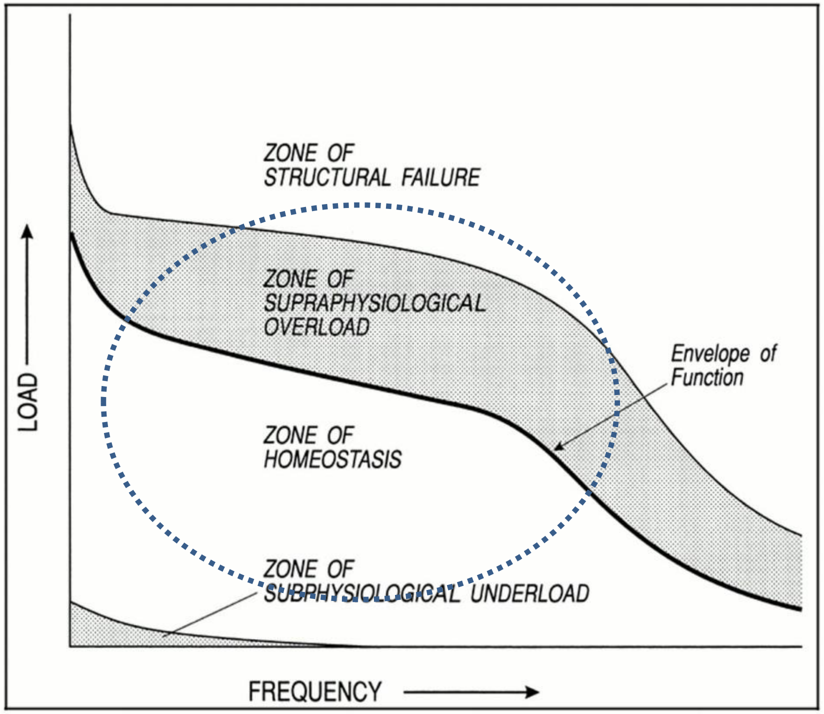
Load Carriage:
Body Armor
Ruck



Sports/Recreation
PT/PRT
Strength Training
Sports

Distance:
Walk/March/Run

Military Physical Demands → Musculoskeletal Injury



Manageable

Excessive

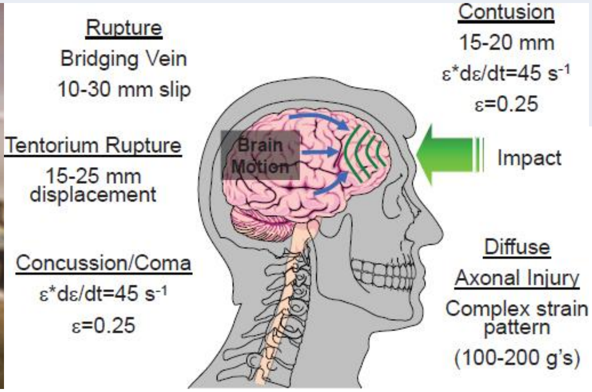
Women in Combat

- On 03 Dec 2015, the Secretary of the Defense (SECDEF) HON Ashton Carter directed the full integration of women in the Armed Forces
- Women in Combat Research Program Goals:
  - Identify best practices for optimizing physical performance of female warriors.
  - Evaluate key nutritional and/or other interventions that may prevent, minimize, and/or treat MSK injury in female warriors.

MILITARY MEDICINE PARTNERSHIP DAYS

Injury Portfolio (additional topics)

Competency	Goal	Subtask	Subtask Goal
Sensory Performance, Injury & Protection	Prevent or mitigate injury to the auditory, vestibular, ocular/facial, head and spine injury.	Blast Acoustic Trauma and Vestibular Injury	Development of validated noise exposure standards that are based on a scientifically validated model to inform design criteria for hearing protection equipment (i.e. situational awareness).
		Development of Neurosensory Return to Duty Standards and Strategies	Develop a validated battery of return to duty performance tests and neurosensory assessments enabling accurate, safe, and rapid decisions regarding the return of Soldiers to specific military occupations after neurosensory injury and TBI.
		Operationally-Relevant Injury Metrics for Improved Soldier Head and Spine Protection	Develop spinal injury criteria under various mounted and dismounted scenarios with the ultimate goal of providing requirements for military vehicle developers (i.e. Head Supported Mass Criteria)
Blast and Ballistic Protection	Provide evidence based injury criteria for the development of personal protective equipment.	Blast and Ballistic Trauma	Develop validated brain, thoracic, abdominal, upper and lower extremity injury criteria when subjected to blunt trauma and behind armor deformation from ballistic threats.



Physiologic Impact of the In-Flight Environment

Ryan Mayes, PhD, MPH
USAFSAM Department of Aeromedical Research
711th Human Performance Wing
19-20 April 2016

Purpose

To increase understanding of the impacts of in-flight environments to human physiology and of sensor needs for those environments. Two major settings will be discussed:

- Operational/Tactical – Fighter Jets
  - Exposures
  - Biomarkers
- Medical – Aeromedical Evacuation
  - Exposures
  - Biomarkers
  - Technology Solutions

711 HPW Sensor Applications: Flight

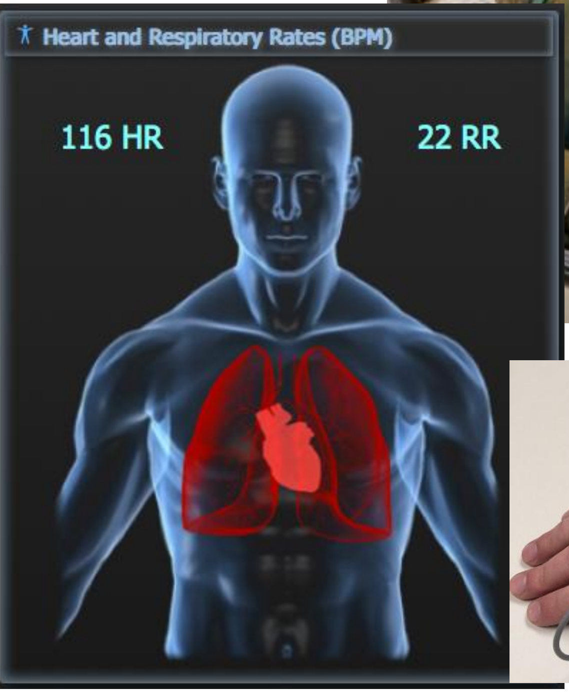
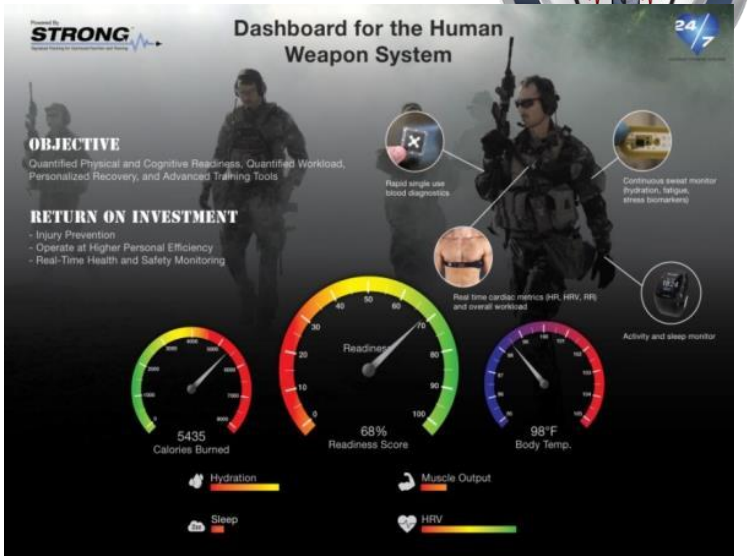


Image courtesy of D. Pohlman and ADAPT team of RHC & RHX

- High-Performance Jets (Current work)
  - Respiratory sensors
  - Aircraft air supply sensors
  - Heart rate
  - Pulse oximetry
- High-Performance Jets (Near Term)
  - Hydration
  - Biomarkers (VOCs) for cognitive and physical fatigue
- Aeromedical Evacuation
  - Wrist-mounted vital sign monitors
  - Continuous monitoring of patient SpO_2
  - Patient intracranial pressure monitoring
  - Biomarker sensing for TBI

Other 711 HPW Sensor Work

- COTS Testing and Development
  - Current work: Special Operators and elite athletes
  - Sweat sensors
  - Applications of flexible electronics
  - Ruggedized COTS devices
  - Developing integrated systems
  - Point-of-care assays
- Needs
  - Environmental extremes
  - Longevity (days of use)
  - Performance Regime
  - Security
  - Reliability



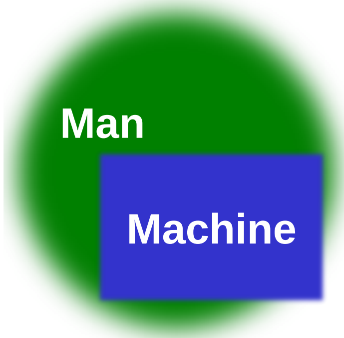
New Approach to Fighter Physiology

Early 20th Century

- Keep the human alive

The Type B-6 winter flying helmet, with earphones, showing method of attaching the Type A-9 oxygen mask. (SI Photo 81-327)

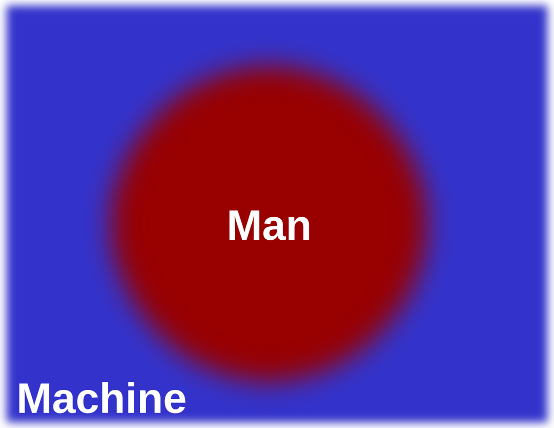
Photo courtesy of Smithsonian Institution, "Combat Flying Clothing" by Sweeting



Today

- Optimize the pilot's performance

Courtesy of Warren Carroll



Courtesy photo/Lance Cheung

In-Flight Environment: Operational

Two broad categories critical to understanding operational in-flight environment and performance (with current work and capability):

1. Inputs to Pilots (Exposures)
   - *Gz*
   - *Altitude*
   - *Breathing gas pressure/flow*
   - *O_2*
2. Outputs from Pilots (Biomarkers)
   - *Cardiorespiratory*
   - *SpO_2*


U.S. Air Force photo/TSgt Justin D. Pyle


Personal Photo

In-Flight Environment: Operational

Current Gaps – Inputs to Pilots

1. Aircraft Monitoring
   - *Small, real-time sensing*
   - *Breathing gas: O_2, pressure, flow*
   - *Breathing air quality (contaminants)*
   - *Older jets: altitude, acceleration*
   - *Vibration?*

2. Knowledge Research
   - *Toxicology / combined effects*
   - *Effects of vibration on sensors*
   - *Near-eye displays and symbology*

U.S. Air Force photo/SrA Sergio Gamboa

U.S. Air Force photo / A1C Anthony Jennings

In-Flight Environment: Operational

Current Gaps – Inputs to Pilots (cont'd)

3. Mitigations
   - *Algorithms for automation (initiation and action)*
   - *Technological solutions to filter / improve breathing gas*
   - *Impact avoidance*


U.S. Air Force photo/MSgt Burt Traynor

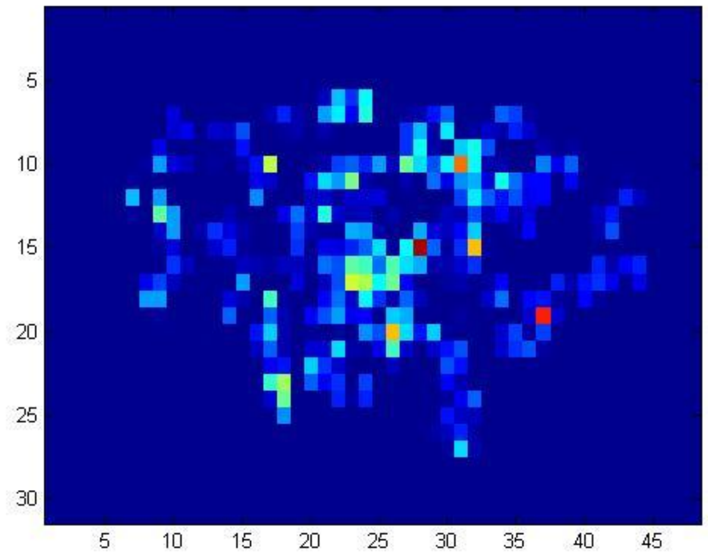
4. Supporting Technology
   - *Power*
   - *Transmission (wireless / non-interference)*


Personal Photo

In-Flight Environment: Operational

Current Gaps – Outputs from Pilots

1. Physiology Monitoring
   - *EOG*
   - *EEG / real-time cerebral activity*
   - *Cerebral perfusion/ cerebral O_2*
   - *Hygrometer*
   - *Core temperature*
   - *Blood pressure*
   - *Improvements to current sensors*



2. Knowledge Research
   - *Human factors*
   - *Biomarkers of badness (fatigue, hypoxia, etc.)*
   - *Human modeling (cell-on-a-chip, physiological system modeling, cognitive modeling)*

In-Flight Environment: Operational

Current Gaps – Outputs from Pilots (cont'd)

3. Mitigations
   - *SD: audio / haptic systems*
   - *Alerts to pilot*

4. Supporting Technology
   - *Power*
   - *Data collection / processing*
   - *Pilot interface*
   - *Transmission (wireless / non-interference)*


U.S. Air Force photo/MSgt Jeffrey Allen

In-Flight Environment: Medical

Broad categories for assessment medical in-flight environment and performance:

1. Inputs to Patients & Personnel (Exposures)
   - *Altitude*
   - *Vibration*
   - *Noise*
   - *Temperature*
2. Outputs from Patients & Personnel (Biomarkers)
   - *Basic medical: HR, BP, SpO_2, temp*
   - *Biomarkers of badness (fatigue, hypoxia, etc.)*
3. Technology solutions
   - *Closed-loop technology / (semi) autonomous systems*
   - *Data transmission, storage, and processing*
   - *Electronic medical record integration*


Personal Photo (Col Sue Dukes)


Personal Photo (Col Sue Dukes)

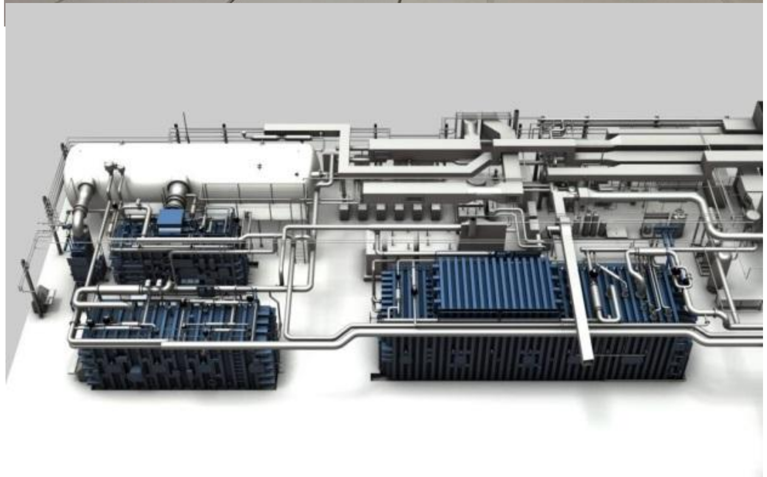

Personal Photo (Mr. Dario Rodriquez)

Technical Challenges

Several major challenges to sensor performance and integration:

- Altitude
- Acceleration (high-performance)
- Vibration
- EMI / transmission
- Integration

Personal Photo



CAD drawing of research chambers

Soldier Readiness Monitor

Ms. Maureen C. Milano
Deputy Project Manager, Medical Support Systems
US Army Medical Research and Materiel Command
20 April 2016

Purpose

To increase understanding of real-time physiological status of dismounted Soldiers.

- *Soldier-worn physiological monitor/sensors*
- *Open architecture*
- *Secure wireless communication with Leaders and Medics*
- *Creates actionable information for Soldier and Leaders to make an informed decision*
- *Small, lightweight, and lasts for an extended duration*

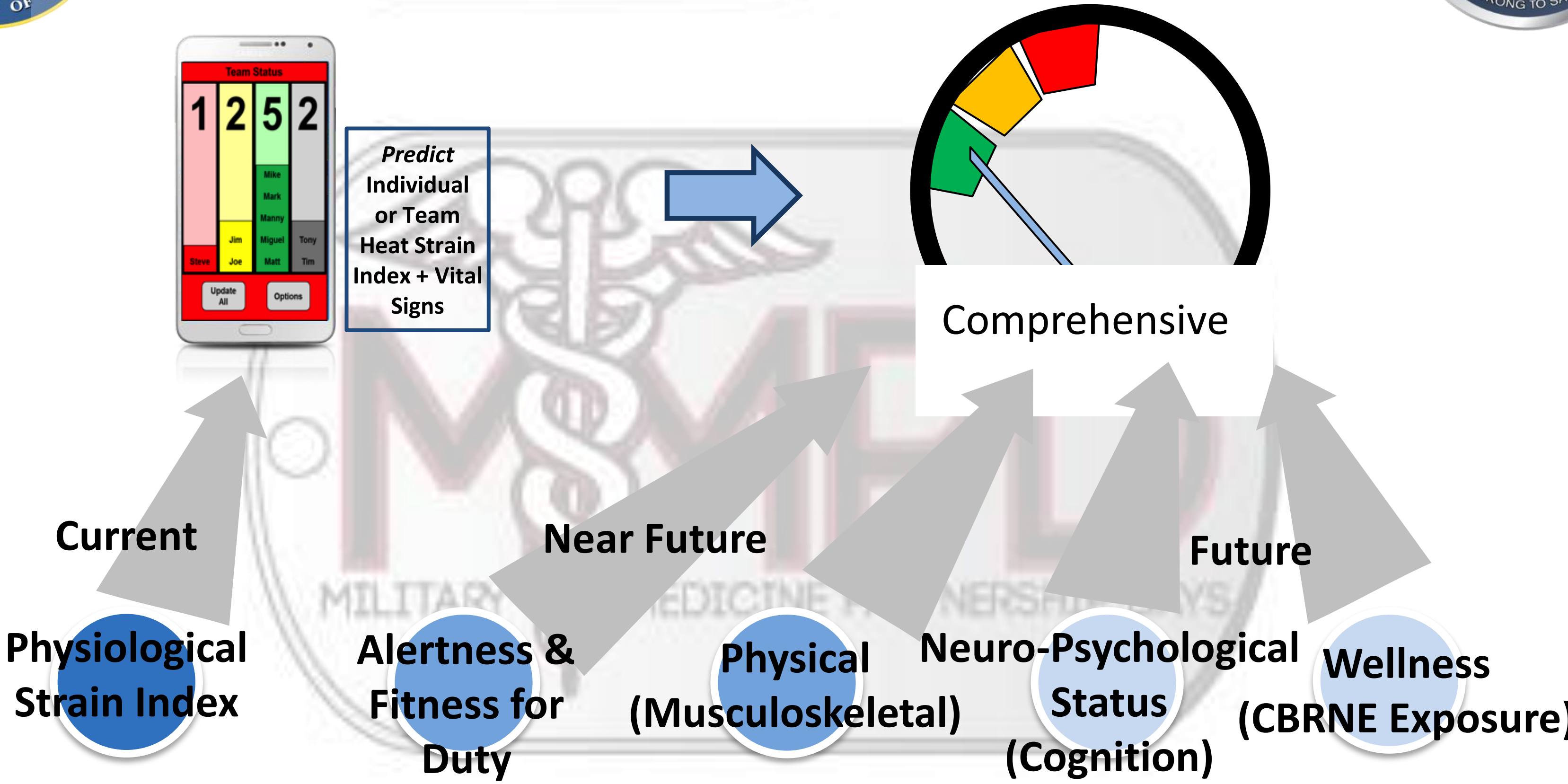
Future Integration

1. Improve Actionable Information (Soldier Readiness Score)
   - *Currently based on the physiological strain index (heart rate based)*
   - *Additions to a comprehensive Soldier Readiness Score*
     - *Cognitive Load*
     - *Alertness/Fatigue*
     - *Musculoskeletal Load*
     - *Electrolytes*
     - *Metabolism*
     - *Chemical and Biological Exposure*

2. Improve Communication Medium for Secure Wireless
   - *Currently using Bluetooth Low Energy (BTLE)*
   - *Operational environment requires Ultra-wide Band and Tunable Narrow Band are more secure*

3. Improve Size, Weight, and Power (SWAP)
   - *Currently runs continuously for 8 hours*
   - *Must run continuously for 72 hours, requires less power consumption and size reduction*

Soldier Readiness Status



Integrating sensors, algorithms and analytics into a Comprehensive Soldier Readiness Status for improved performance

Questions?

For additional questions after the conclusion of the conference, send an email message to usarmy.detrick.medcom-usamrmc.mbx.mmpd@mail.mil