Digital Soldiers: Transforming Personalized Health in Challenging and Changing Environments

CREATING THE FUTURE FOR MILITARY MEDICINE

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About TATRC

Need for advances in personalized health

Program developments

Summary and outlook
Explore science and engineering technologies ahead of regularly programmed research, leveraging other programs to maximize benefits to military medicine.

Be the model government enabler of technology transfer to use.
**TATRC KEY INITIATIVES**

- **e-HEALTH**
  - Cell phone-based systems
  - Remote biomonitoring
  - Global Biosurveillance

- **MEDICINE IN AUSTERE ENVIRONMENTS**
  - Robotic rescue & evacuation
  - Shelf stable diagnostics & vaccines
  - Blood products & blood safety

- **DIGITAL WARRIOR**
  - Natural orifice transluminal endoscopic surgery
  - Advanced medical imaging
  - Distance medical training & simulation

- **HOSPITAL OF THE FUTURE**
  - Operating room of the future
  - Prosthetics and human performance
  - Regenerative medicine & biomaterials

- **INTEGRATIVE MEDICINE**
  - Virtual environments
  - Computational models & tools
  - Human/soldier phenome
  - Performance & injury prediction models
  - Cell phone-based systems
  - Remote biomonitoring
  - Global Biosurveillance
Need for advances in personalized health
MILITARY HEALTH SYSTEM PRIORITIES

• Enhance warrior care
  – Strengthen the continuum of care from entry to service to rehabilitation and transition

• Build a bridge to peace
  – Expand humanitarian missions and disaster relief to support US strategic objectives and champion aspirations for human dignity through better health

• Promote patient choice & accountability, healthy communities, safety & quality

• Strengthen medical education & research

• Create healing environments
Urgent military needs drive demand for better solutions.

Military is often “early adopter” of new medical technology.

“Dual use” applications flow to civilian use.

Continuous monitoring from readiness to reset.

Rehab/Reset → Training → Tactical

Fixed Facility → Evacuation
CONFLUENCE OF TECHNOLOGIES = PERSONALIZED HEALTH

• **Cell phone connectivity** - individual access to personalized resources
• **Electronic health record** – portable, accurate, personalized to “learn its soldier”
• **Phenomics** – comprehensive physiological models that interpret and predict the individual
• **Closed loop systems** – highly reliable monitoring and feedback to support the individual
• **Integrative health** - empowered people with responsibility for their own health and wellness

*Biomonitoring technologies are critical to each of the goals*
Better compliance
Better care
Greater efficiency = lower cost

Reminder
Title: Appointment Reminder
From: Staff
Date: 12/12/08 @ 1330
Message: Reminder: You have an appointment at American Therapy services on Monday, 12/15/08 @ 1000.
**CELL PHONE CONNECTIVITY BETWEEN PATIENT AND HEALTH CARE PROVIDER**

### INDIVIDUAL AWARENESS FOR ACTION

There is no requirement for complexity!

### mCare Web Portal - Dashboard

<table>
<thead>
<tr>
<th>Question Status</th>
<th>Message/ Goal Center</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Wellbeing</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Physical Pain</strong></td>
<td>Extent of Pain, Severity of Pain, Change in Pain Levels, Impact of Daily Activities</td>
</tr>
<tr>
<td><strong>Anger Management</strong></td>
<td>Temper Control, Anger Interfering at Work, Anger Interfering at Home</td>
</tr>
<tr>
<td><strong>Relationships</strong></td>
<td>Getting Along with Family/Spouse, Getting Along at Work, Impact on Work</td>
</tr>
<tr>
<td><strong>Mood</strong></td>
<td>Life Satisfaction, Good Spirits, Future Outlook</td>
</tr>
<tr>
<td><strong>Monthly Weight</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Energy & Sleep**
- Energy Level
- Energy Daily Activities
- Sleeping
- Hours of Sleep

**Comprehensive Transition Goal Plan**
- [ ]

Add a note...
We monitor vehicles and equipment for fatigue and failure better than we do humans.

- biomonitoring of person & decision support tools (“skin-in”)
- record of individual environmental exposures (“skin-out”)
- virtual “friend” for stress management
- medical advice to extend limited physician access (virtual medic)
- automatic “911” for medical alert
1.8 B cell phones in the developing world

1 M new cell phones every day

The explosive spread of mobile phone networks across the developing world has created a unique opportunity to significantly transform how countries can tackle global health challenges.

Dr. Howard Zucker, Assistant Director-General, WHO
SURGICAL TELEMENTORING

System Development

Deployment 47th CSH, Iraq
Hospital-acquired infections cause at least 88,000 deaths annually and cost $4.5B

Personal monitoring: from federal to general healthcare to food industry

“Protection Zone” transmitters send out unique, short range signals near food prep stations, bathrooms, patient beds, etc.

Small receivers worn by staff, vibrates when washing should occur – also records when washing has or has not occurred. All data can be downloaded via USB or wireless link.

“Wash Zone” transmitters send out signals when hand washing has occurred.

Protected Zone

Food Prep Area

Transmitter

Wear Monitor

Wear Device
• Standards-based exchange of health information

• Infrastructure facilitates health information exchange between DoD, federal partners, and civilian participants

Decouple data exchange process. Connect via standard web services.
Simplify record keeping, medical examinations and provide immediate and secure access to medical data in emergency or normal healthcare use.

Gives medical personnel accurate and instantaneous access to patient medical records at a distance of 10m, without physical contact.
SPARNET is an integrated system for capture, analysis, communication, display, and archive geo-location and physiologic-sensor data.

Real time medical status data and geo-location for increased safety during training.
**MEDICAL SITUATIONAL AWARENESS FOR COMMANDERS AND MEDICS**

**PERVASIVE HEALTH MANAGEMENT**

- Cognitive State
- Metabolic Monitoring
- Thoracic Sensor
- Textile Based Sensors
- Enhanced Remote Triage
- Life Saving Interventions
- New Hydration Assessment Technologies
- Lab on Chip
- Noninvasive Cardiac Output

**Adaptive Models**
- “Learn” Individual “Normal”

**Better Sensor Fusion**
- Electro Textiles
- Stealth Wireless Network

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

**Enhanced Technologies**
- Saturated Pulse Oximetry
- Cardiac Output
- Blood Pressure
- Lab on a Chip
- Neurological Assessment
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COMMON THEMES FOR PERSONALIZED MONITORING

CONCEPTS FOR THE FUTURE SOLDIER FROM NATO ALLIES

FFW (Future Force Warrior)  IdZ (Infanterist der Zunkunft)

FELIN (Fantassin à Équipements et Liaisons Intégrés)

NORMANS

FIST
There are many energy expenditure measurement devices.

Health monitoring also requires energy intake monitoring solutions.
Dead Reckoning Navigation System
Total weight + geolocation + USARIEM Equation
Metabolic cost of locomotion

GPS Wrist monitor
(Garmin Fortrex 201)

GPS + magnetic compass + electronic pedometer + solid state gyro + altimeter

http://www.pointresearch.com
Provides for continuous monitoring of the soldier’s metabolic and medical status, combined with telemetry for remote situational awareness of a Warfighter’s physiological and medical condition.
Acoustic wave sensors are unique platforms that are capable of sensing multiple bio markers and manipulating bio-films.

Surface acoustic wave sensor combined with a biofluid collection system will enable for measurement of biochemical changes occurring after injury.
SMART HOME CONCEPT

- in-home sensor network optional
- wearable, physiological devices
- indoor GPS tracking

Remote, home monitoring of soldier’s health status combined with interactive cognitive interface for soldier’s rehabilitation.
The CAREN system for rehabilitation and retraining
Pneumatic balloon actuators for tactile feedback

NEUROPSYCHOLOGICAL STATUS MONITORING

Testing and behavioral status monitoring embedded in games and regular activities
EYE TRACKING FOR SCREENING FATIGUE AND TBI

HEALTH INFORMATION FOR ACTION

Non-invasive screening for determination of soldier’s fitness for duties
WEARABLE, WIRELESS PHYSIOLOGICAL
STATUS MONITORING

MEASURES:
- SpO2
- HR
- RR
- Perfusion Index
- Posture
- Activity
- Skin Temperature

Provides for continuous monitoring of the soldier’s physiological status, combined with telemetry for remote situational awareness of a Warfighter’s physiological and medical condition.
Examples of nonverbal signals that may be diagnostically important:

- voice stress
- eye movement
- body position
- movement
- physiological responses

“Justina” – interactive PTSD patient to train new physician interview techniques

Personal projections and biofidelic artificial intelligence interactions need biomonitoring data from nonverbal signals
INTELESENSE TECHNOLOGIES AND
PROJECT ARGUS

Provides real-time public health status and environmental situational awareness through combination and integration of data from wireless sensors and public health information through the web and other databases.
• Self-contained teleoperated proximity system for detection and identification of chemical, biological, nuclear, radiological and explosive (CBNRE) agents on environmental surfaces

• Sensing technology based on spatially-resolved Raman spectroscopy capable of the high levels of discrimination required for environmental analysis
Reliability of measurements and predictions
Transparency and open architecture
Interoperability
Validation and certification
Personal data privacy
Cost effectiveness
Wear-and-forget convenience
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