Military Medicine Partnership: Naval Challenges

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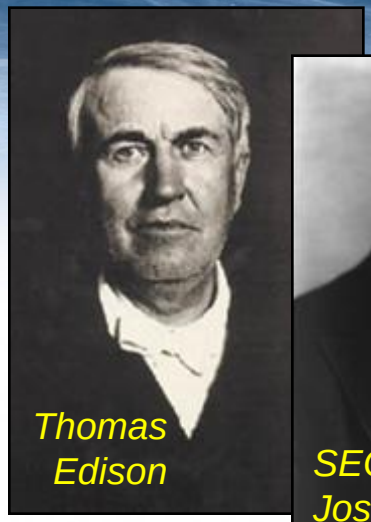
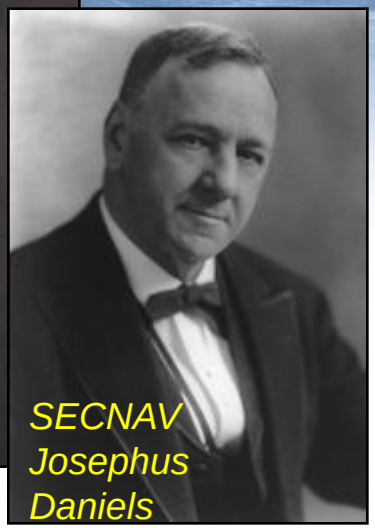
ONR Beginnings

Naval Research Laboratory

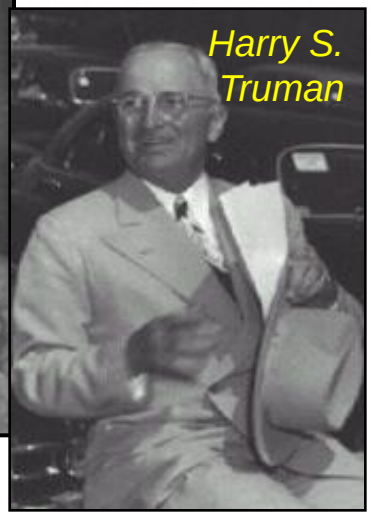
(Appropriations Act, 1916)

"[Conduct] exploratory and research work … necessary … for the benefit of Government service, including the construction, equipment, and operation of a laboratory…."


Thomas Edison


SECNAV Josephus Daniels


Vannevar Bush


Harry S. Truman

Office of Naval Research

(Public Law 588, 1946)

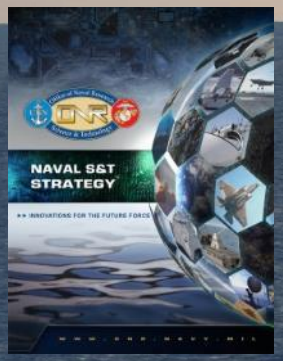
"… plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security…. "

Sustained Support for Science & Technology

The Office of Naval Research

The S&T Provider for the Navy *and* Marine Corps

- 4,000+ People
- 23 Locations
- $2.1B / year
- >1,000 Partners



Discover → Develop → Deliver → Technological Advantage

Naval S&T Investment Balance

Broad

Focus

Narrow

5-20 years

Discovery & Invention (Basic and Applied Science)

≈ 50%

4-8 years

Leap Ahead Innovations (Innovative Naval Prototypes)

≈ 12%

2-4 years

Technology Maturation (FNCs, etc)

≈ 30%

1-2 years

Quick Reaction & Other S&T

≈ 8%

Current Fleet/Force

Fleet/Force in Development

Future Fleet/Force

~ 50% Focused on Near & Mid-Term Capabilities

ONR is part of the NR&DE, Providing Full-Spectrum RDT&E

RDT&E Budget (6.1-6.7)

S&T Budget (6.1-6.3)

6.1 Basic Research	6.2 Applied Research	6.3 Advanced Technology Development	6.4 Adv. Comp. Development & Prototypes	6.5 System Development & Demonstration	6.6 RDT&E Management Support	6.7 Operational System Development

Naval R&D Establishment

(ONR, SYSCOMs and their Warfare Centers, PEOs)

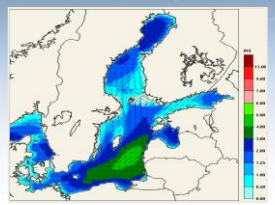
Office of Naval Research

SPAWAR

NAVSEA NAVAL SEA SYSTEMS COMMAND

NAVAIR

Naval S&T Focus Areas



Assure Access to the Maritime Battlespace

- Ocean/Atmospheric Sciences
- Underwater Acoustics
- Ocean Sensing

Autonomy and Unmanned Systems

- Robotics
- Machine Learning
- Perception
- Human Machine Interface

Expeditionary and Irregular Warfare

- Situational Awareness
- Decision Making
- Mobility / Logistics
- Soldier Protection

Information Dominance / Cyber

- Communications / Information Technology
- Computer Science
- Mathematics /Data Analytics

Power Projection and Integrated Defense

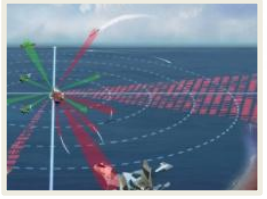
- Directed Energy
- Energetic Materials

Platform Design and Survivability

- Air/Surface/Subsurface Vehicles
- Materials
- Corrosion /Biofouling
- Manufacturing Technologies

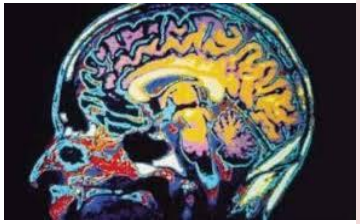
Power and Energy

- Renewable Energy
- Propulsion
- Power Control
- Thermal Management



Electromagnetic Maneuver Warfare

- EM Propagation & Waveforms
- Sensors and Electronics
- Optical Systems

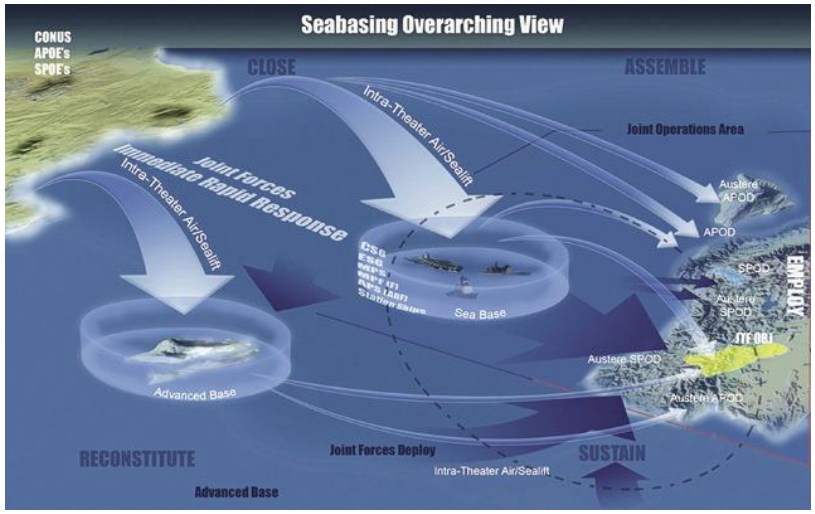


Warfighter Performance

- Biomedical / Bioengineeering
- Cognitive / Neural Sciences
- Training Technologies
- Force Health Protection

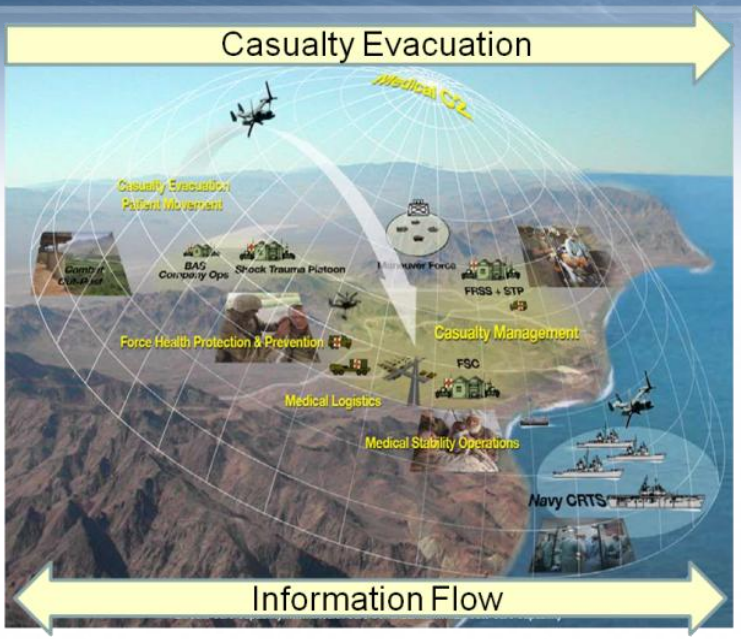
Operational Challenges

"Over the horizon force projection with operational reach approaching 240 nautical miles (nm) will … increase the risk of in-transit clinical degradation of severely wounded casualties." "The Naval Fleet and the Marine Corps lack the capability to safely transport…over the times and distances expected in Expeditionary Maneuver Warfare".
(USMC ORD for The En Route Care System)



Current C4I systems do not provide operational and clinical situational awareness to nonmedical C4I systems, and patient movement and personnel tracking systems do not interact and are labor-intensive. ***(NAVY WARFARE DEVELOPMENT COMMAND (NWDC) TACMEMO 4-02.2-14)***

The Challenge: Trauma Care on the Battlefield



Due to remoteness of military operations, patient holding times may range from between 6 to 72 hours before transport to a medical center is possible

"Unlike in the US and other developed countries, medical care in military operations or in disaster relief efforts involves **long times and distances** before the casualty arrives at to advanced medical care."

Casualty Evacuation Is a Complicated Bi-directional Information Network

Enroute Critical Care System

- Patient status communication between Distributed Navy and Marine Operations ashore and the Seabase
- Constant patient monitoring and treatment during movement of patients during ship to ship, shore to ship and during En route Care flight transfers
- Reduces effects from the ***"Tyranny of Distance"*** as we move from CENTCOM to AFRICOM and PACOM Areas of Responsibilities

Patient tracking is not just about moving people, it is about knowing what a person needs so you can make a decision about a person in a quick and organized way. (*A MODEL FOR NATIONWIDE PATIENT TRACKING, 2009*)

Pivot to the Pacific: A Bigger Place to Maneuver

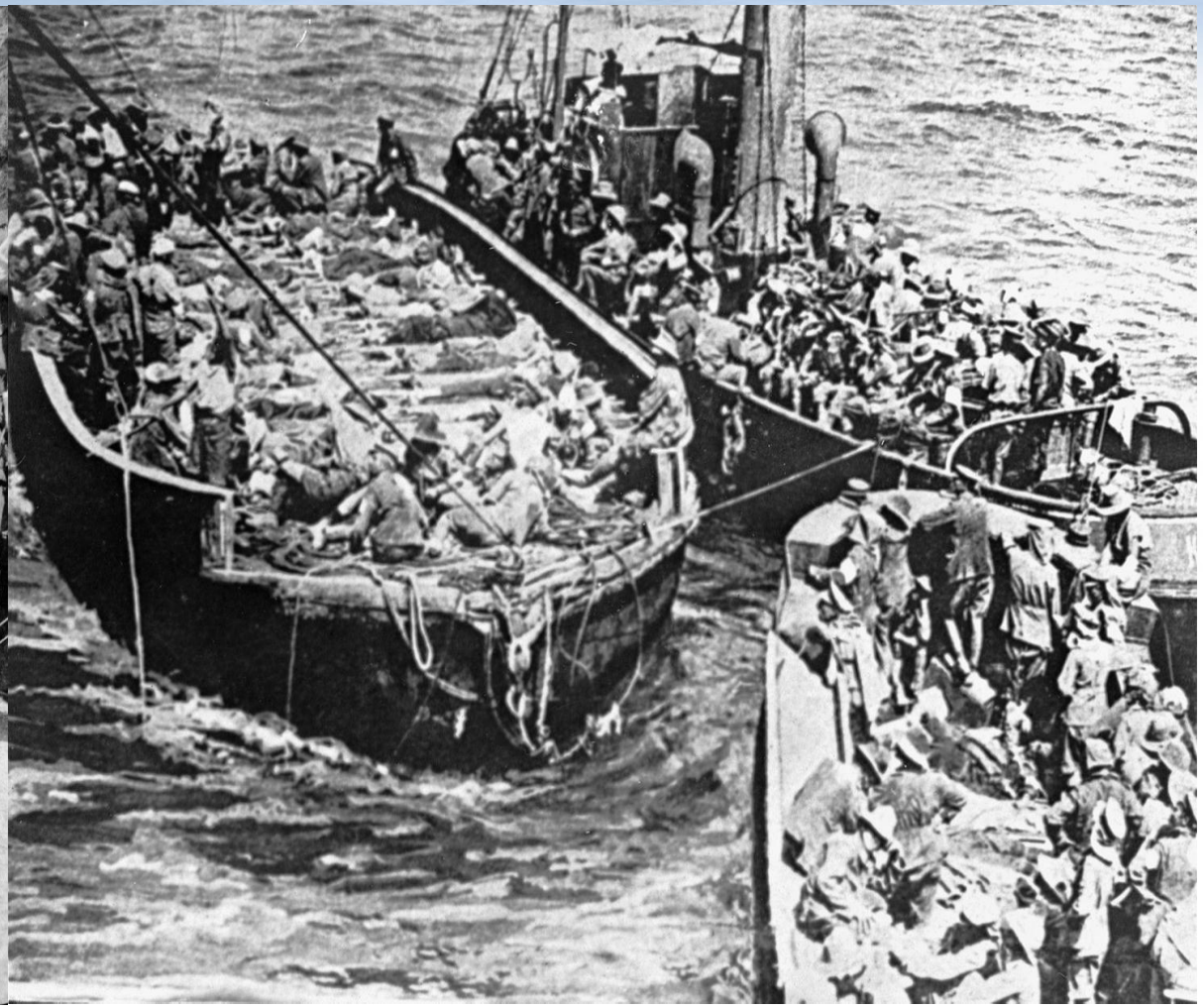
Pacific Ocean (155,557,000 sq km) **Atlantic Ocean**(76,762,000 sq km)

The Challenges of Africa

11.67 million sq miles (30.22 million km²)

HADR and distributed operations, the number of casualties exceeds medical staff and evacuation capacity.

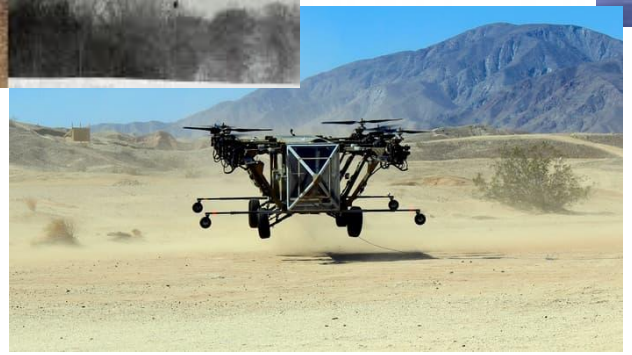
Medical Transportation Then……



Medical Transportation Now……

The Future Transport: CASEVAC by UAV/UGV/USV

"Due to evolution of future Seabasing, ability to support Ship-to-Objective Maneuver (STOM), and establishment of Enhanced Company Operations (ECO), the Corps requires… unmanned platforms" (USMC UNS for UAS)



Team Retiarius UGCV

The ACCS is an essential enabler of CASEVAC by unmanned platforms

Today's Ships
Challenge Patient Movement onboard





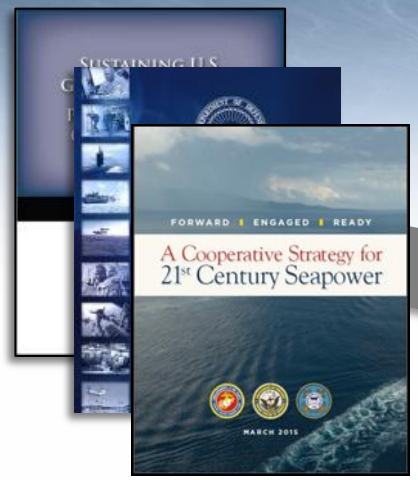


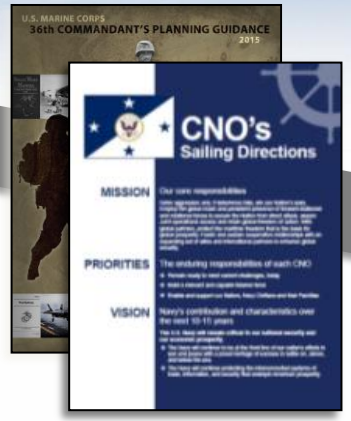




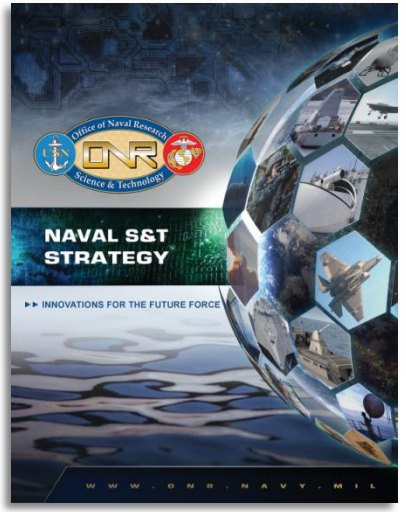

Medical Space Unique Challenges onboard Naval Platforms

Strategic Guidance is the Foundation for our Naval S&T



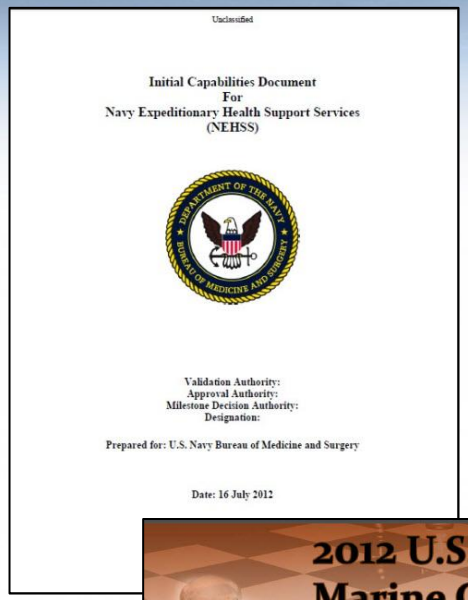


National & Naval Strategy/Direction



Warfare Enterprise's S&T Objectives

A Sample of Guiding Documents

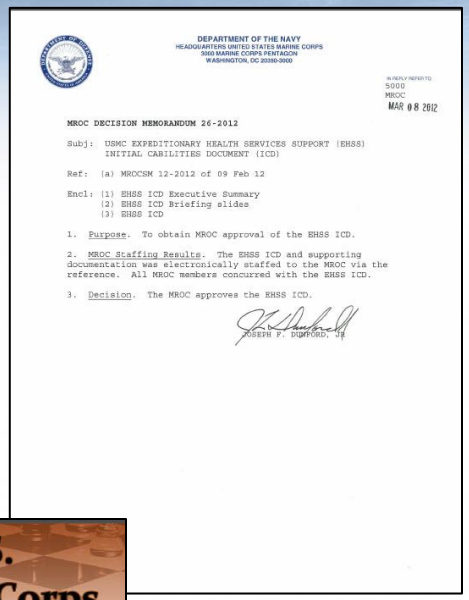

Unclassified

Initial Capabilities Document
For
Navy Expeditionary Health Support Services
(NEHSS)

Validation Authority:
Approval Authority:
Milestone Decision Authority:
Designation:

Prepared for: U.S. Navy Bureau of Medicine and Surgery

Date: 16 July 2012


DEPARTMENT OF THE NAVY
HEADQUARTERS UNITED STATES MARINE CORPS
3000 MARINE CORPS PENTAGON
WASHINGTON, DC 20350-3000

5000
MROC
MAR 08 2012

MROC DECISION MEMORANDUM 26-2012

Subj: USMC EXPEDITIONARY HEALTH SERVICES SUPPORT (EHSS) INITIAL CABILITIES DOCUMENT (ICD)

Ref: (a) MROCSM 12-2012 of 09 Feb 12

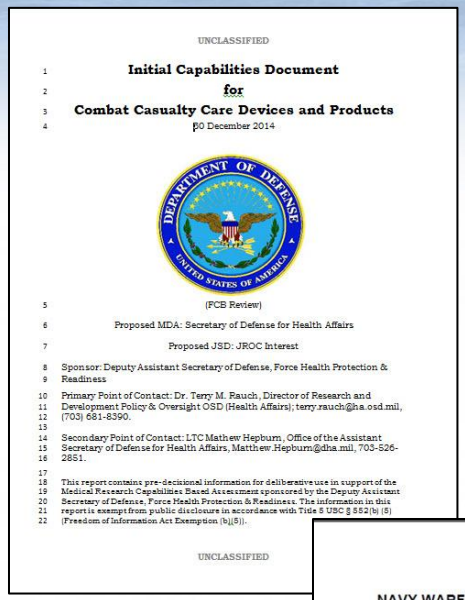
Encl: (1) EHSS ICD Executive Summary
(2) EHSS ICD Briefing slides
(3) EHSS ICD

1. Purpose. To obtain MROC approval of the EHSS ICD.

2. MROC Staffing Results. The EHSS ICD and supporting documentation was electronically staffed to the MROC via the reference. All MROC members concurred with the EHSS ICD.

3. Decision. The MROC approves the EHSS ICD.

JOSEPH F. DUNFORD, JR.


UNCLASSIFIED

Initial Capabilities Document
for
Combat Casualty Care Devices and Products

10 December 2014

(FCB Review)

Proposed MDA: Secretary of Defense for Health Affairs

Proposed JSD: JROC Interest

Sponsor: Deputy Assistant Secretary of Defense, Force Health Protection & Readiness

Primary Point of Contact: Dr. Terry M. Rauch, Director of Research and Development Policy & Oversight OSD (Health Affairs); terry.rauch@ha.osd.mil, (703) 681-8390.

Secondary Point of Contact: LTC Mathew Hepburn, Office of the Assistant Secretary of Defense for Health Affairs, Matthew.Hepburn@dha.mil, 703-526-2851.

This report contains pre-decisional information for deliberative use in support of the Medical Research Capabilities Based Assessment sponsored by the Deputy Assistant Secretary of Defense, Force Health Protection & Readiness. The information in this report is exempt from public disclosure in accordance with Title 5 USC § 552(b) (5) (Freedom of Information Act Exemption (b)[5]).

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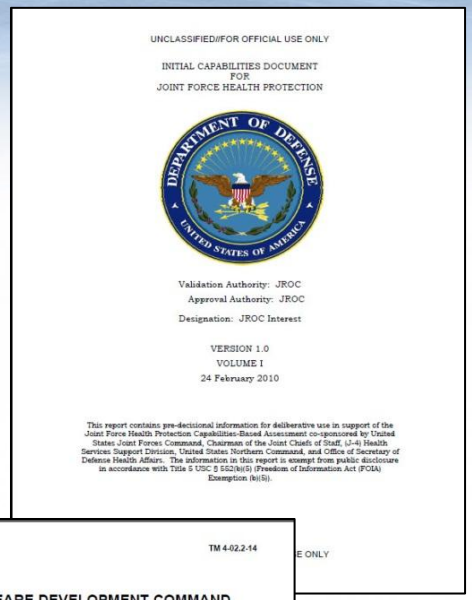
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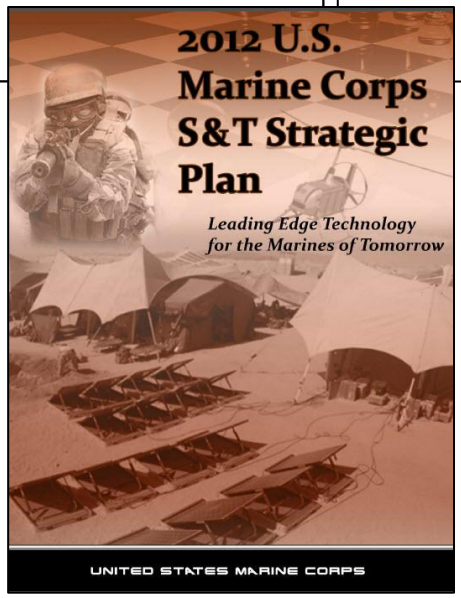
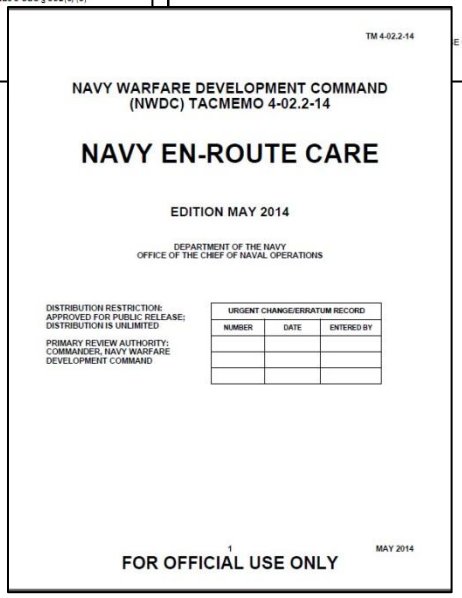
INITIAL CAPABILITIES DOCUMENT
FOR
JOINT FORCE HEALTH PROTECTION

Validation Authority: JROC
Approval Authority: JROC
Designation: JROC Interest

VERSION 1.0
VOLUME I
24 February 2010

This report contains pre-decisional information for deliberative use in support of the Joint Force Health Protection Capabilities-Based Assessment co-sponsored by United States Joint Forces Command, Chairman of the Joint Chiefs of Staff, (J-4) Health Services Support Division, United States Northern Command, and Office of Secretary of Defense Health Affairs. The information in this report is exempt from public disclosure in accordance with Title 5 USC § 552(b)(5) (Freedom of Information Act (FOIA) Exemption (b)(5)).




TM 4-02.2-14

NAVY WARFARE DEVELOPMENT COMMAND
(NWDC) TACMEMO 4-02.2-14

NAVY EN-ROUTE CARE

EDITION MAY 2014

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS

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PRIMARY REVIEW AUTHORITY:
COMMANDER, NAVY WARFARE
DEVELOPMENT COMMAND

URGENT CHANGE/ERRATUM RECORD

NUMBER	DATE	ENTERED BY

1

MAY 2014

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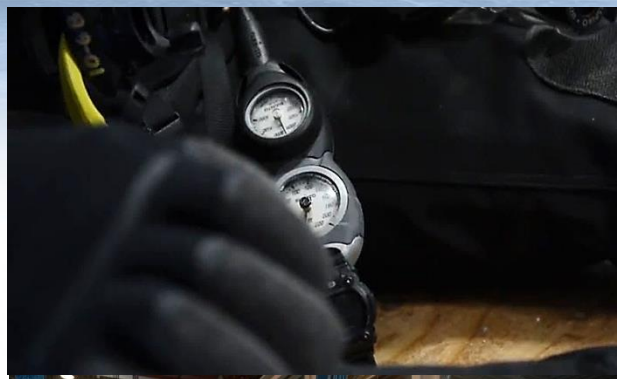
Initial Capabilities Documents

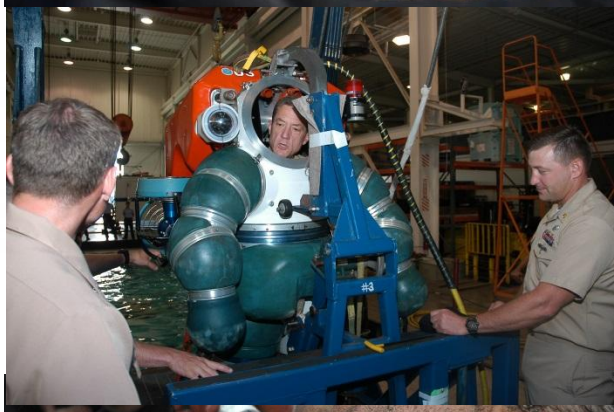
i. Navy Expeditionary Health Support Services
ii. USMC Expeditionary Health Support Services
iii. Combat Casualty Care Devices and Products
iv. Joint Force Health Protection

Science and Technology Strategic Plan

i. USMC S&T Plan

Navy Diving "State of the Art"





Undersea Medicine
National Naval Responsibility

Biometric Monitoring desired because of the extreme environment

- Need for a breathing apparatus
- Hyperbaric pressure
- Thermal stress
- Dark with limited means of communication

Start with basic physiological measurements

- Respiration rate
- Heart rate/variability
- Core temperature

Technical challenge

- Seawater and sensors/electronics don't mix
- Can't use wireless



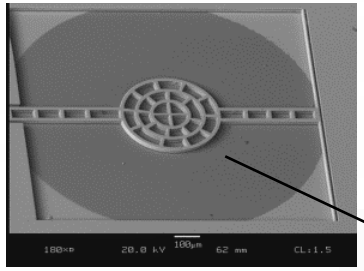

Challenges of Blast / High Energy Events

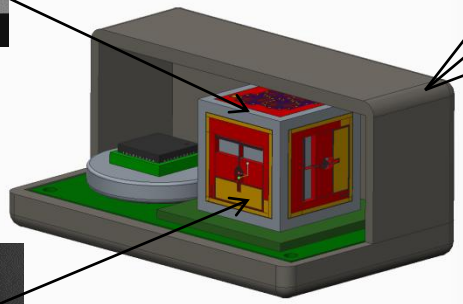
MEMS Sensors for BLAST

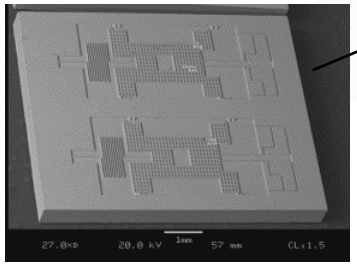
MEMS: Micro-Electromechanical Systems

- Objective
  - To design and demonstrate minimally powered (or un-powered) inertial and pressure sensors to detect and quantify blast loads capable of inflicting mTBI.
- Proposed solution
  - Develop threshold MEMS sensors with mechanical switch closures to indicate blast exposure
  - Momentary contact for minimally powered version
  - Latching switch for un-powered version
- Status
  - Conducting laboratory testing of sensors and electronics
  - Tactical prototype expected Q4 FY16

- **Technical Gap**
  - **Current sensors require power to operate**
    - **Battery life causes service life limitation**
    - **Larger batteries become too bulky**
  - **Commercial sensor approach requires data reduction**
    - **While detailed data is good for blast wave analysis, it may be burdensome when a quick yes/no exposure is desired**



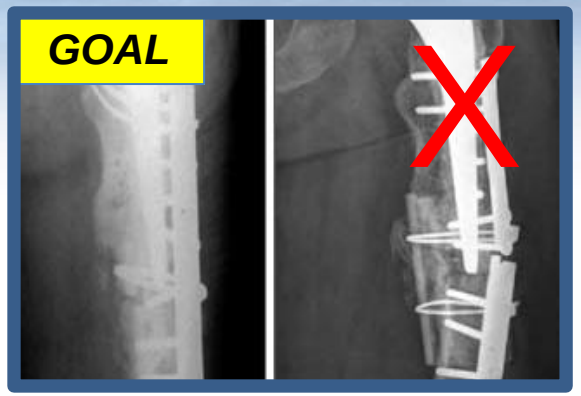


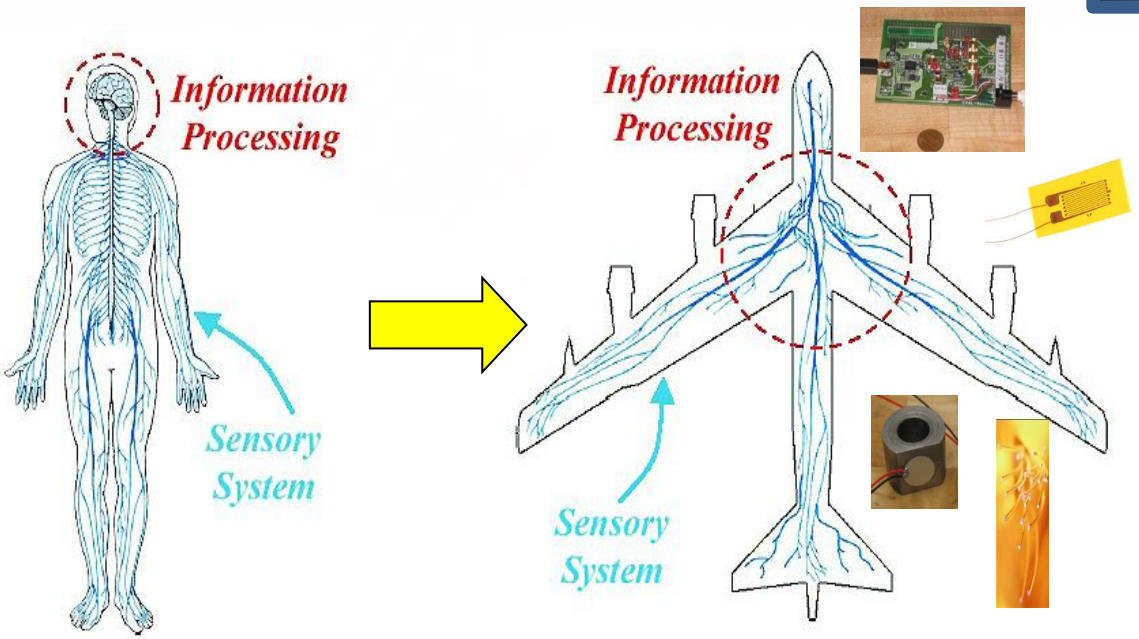


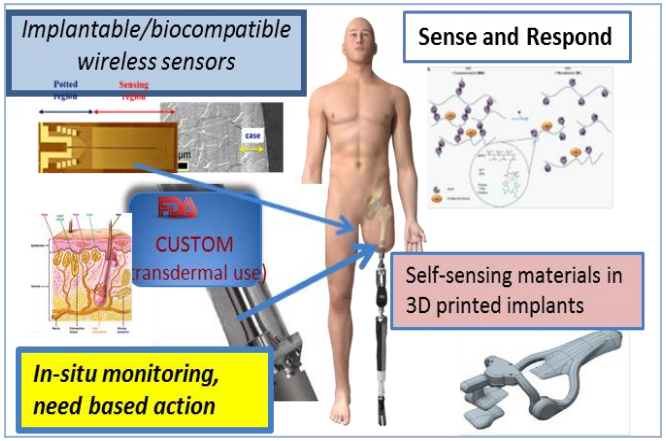
Structural Health Monitoring for Health: Multidisciplinary Field

- *What is SHMH?*

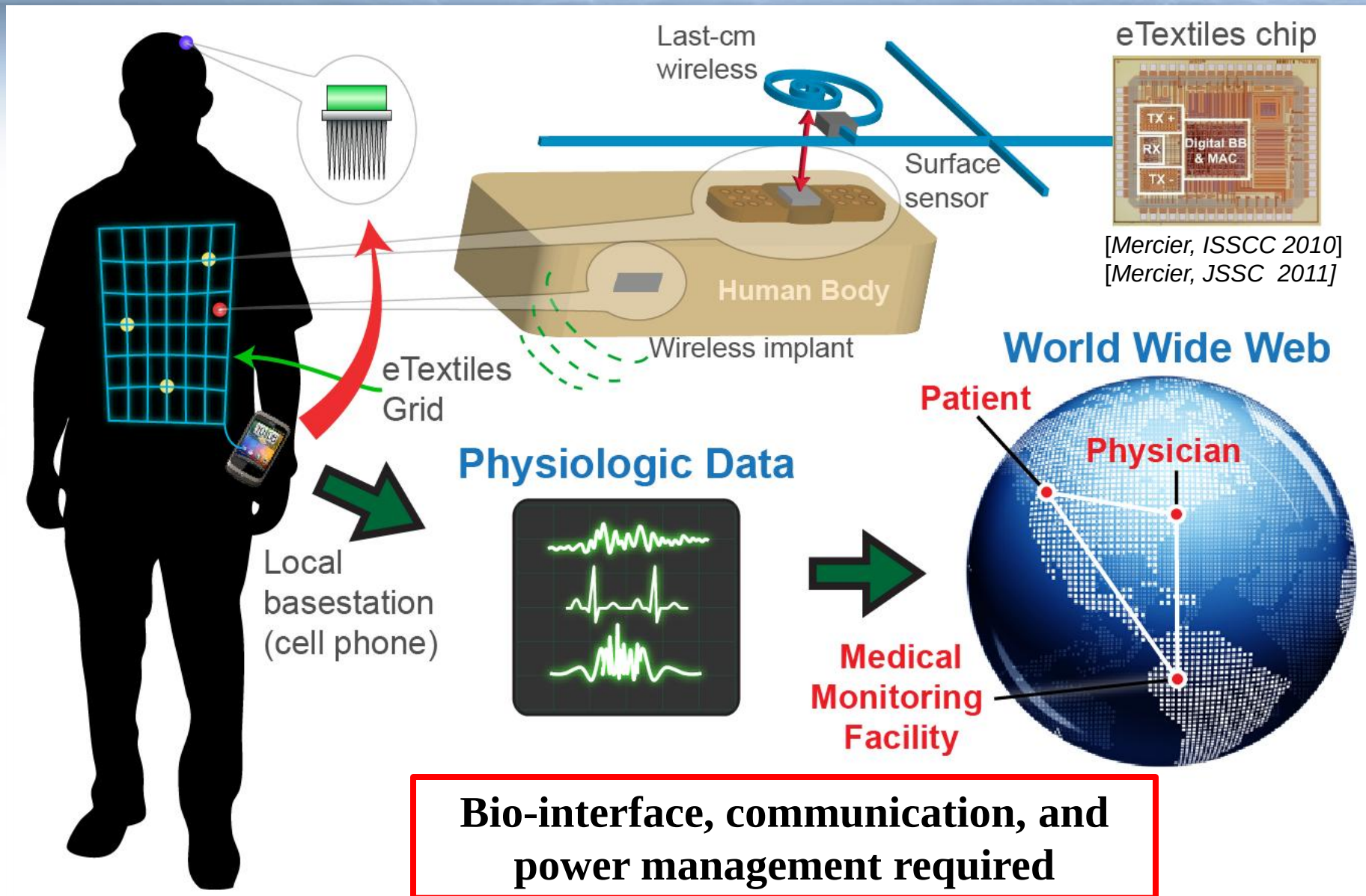
  Structural Health Monitoring is the process of developing a damage assessment capability for aerospace, civil and mechanical infrastructure







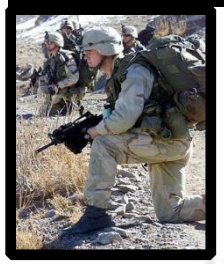
Enabling vision: Body Area Networks



[*Mercier, ISSCC 2010*]
[*Mercier, JSSC 2011*]

Bio-interface, communication, and power management required

Altitude-Induced Hypoxemia



High Altitude Sickness

42% incidence of Acute Mountain Sickness

~3000m

~2100m– 2700 m

22% incidence of Acute Mountain Sickness

~ 900 m

At risk of High Altitude Sickness

- AMS
- HAPE
- HACE

- 20% personnel suffered altitude illness during Op Anaconda
- Half of Afghanistan is over 2000m, with an average elevation of 4500m, resulting in mild- to life-threatening altitude sickness in un-acclimatized Warfighters.
- US Security Analysis: > 60 world-wide high altitude areas for possible military engagement
- HAPE/HACE may reach as high as 15%, and one incident can compromise an entire unit.
- Current treatments are a logistical burden and have side-effects.

Altitude exposure impairs Warfighter health and performance

HYPOXIA – lack of oxygen to tissue

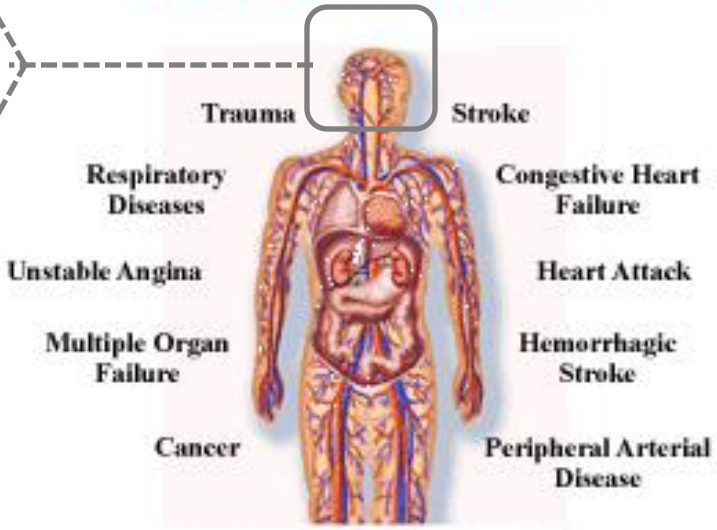
Oxygen deprivation

⇩

Cells/tissues fail/die

⇩

Hypoxic Conditions



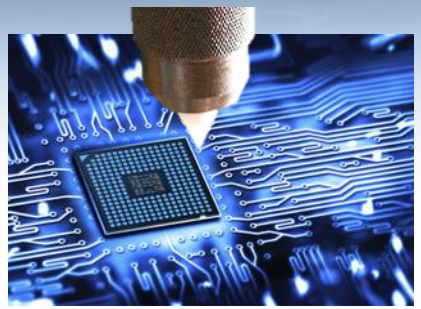
Neurological side effects

Anxiety / Euphoria
Confusion
Impaired Judgment / Memory
Dizziness
Fatigue
Headache
Hot/Cold Flash
Difficulty Communicating
Loss of Muscle Coordination
Numbness
Visual Impairment
Loss of Peripheral Vision
Loss of Consciousness

How to measure or predict hypoxia?

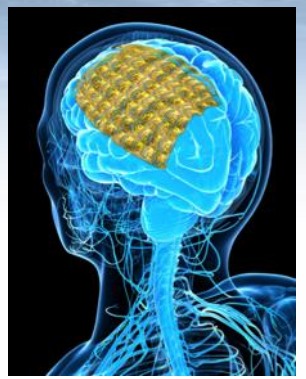
Signs and Symptoms are similar for other physiologic events, such as A-LOC, G-LOC, SD

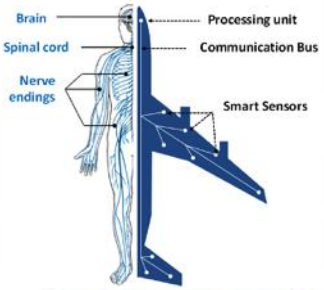
Printed 3D Flexible Electronics: DoD Relevance



Mission specific devices on-demand

Bio-electronic implants and interfaces



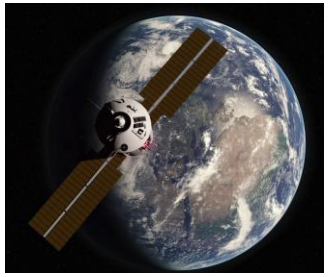


Structure health monitoring

Areas of Implementation

Reconfigurable autonomous systems

Smart skins & wearable electronics



Tracking, tagging & locating

Tunable treatments for low observables

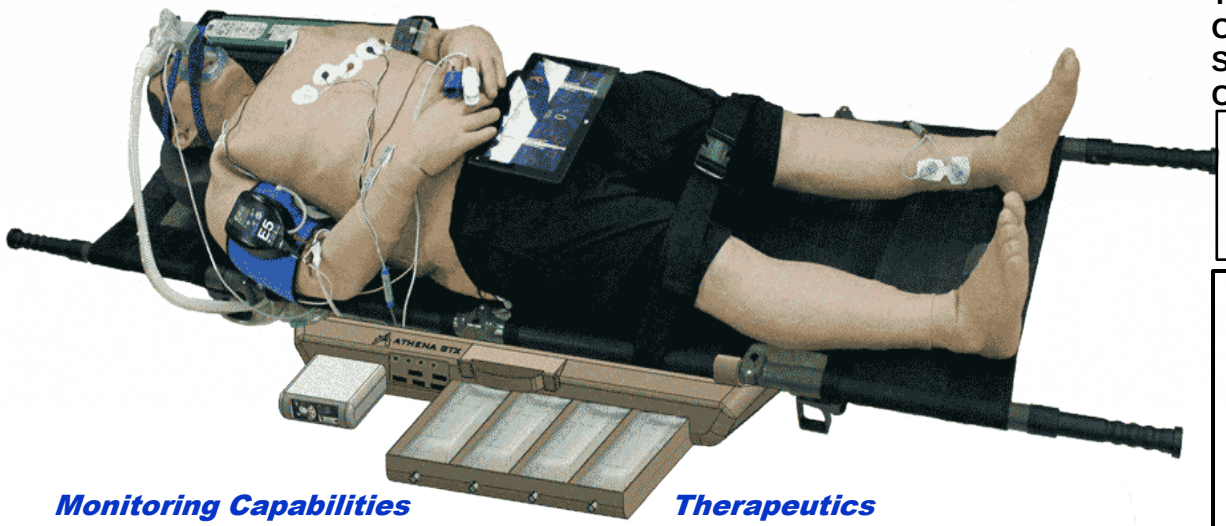
Printed 3D flexible electronics will enable a new generation of systems capable of sensing, actuating, recording, processing and communicating with their surroundings in ways unfeasible today.

A Solution - Automated Critical Care System
Mobile Casualty Monitoring and Care

Automated Critical Care System (ACCS)

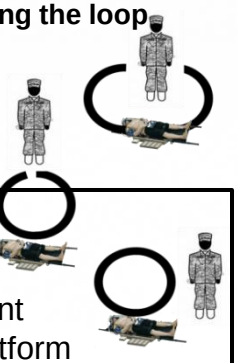
The ICU in a Suitcase

Treating multiple systems in a single patient



Therapeutic interventions:
Open loop or human in the loop
Semi-closed or human on the loop
Closed Loop or human supervising the loop

The more technologies that have to simultaneously work together increases the difficulty



Monitoring Capabilities

- **IV Fluid input**
- **SPO2**
- **Non Invasive Blood Pressure**
- **Cardiac Output**
- **Ventilation to include Volume, Rate Pressure (PEEP)**

Therapeutics

- **Mechanical Ventilation**
- **Supplemental Oxygen**
- **Physiological Monitoring**
- **Casualty and Fluid Warming**
- **Analgesia / Sedation Therapy**
- **Fluid and Drug Infusion**

Challenges:

Hardware Issues:

- ❖ Interoperability of equipment
- ❖ Autonomous Transport Platform Development
- ❖ Battery Technology
- ❖ Lightweight Oxygen Generation

Telemedicine issues

- ❖ Data prioritization / Metering
- ❖ Bi-directional Communications
- ❖ Cybersecurity – Protection from nefarious acts
- ❖ Data Presentation – Easily Understood

Casualty Monitoring and Therapeutic Care

Example of Technology Desires

Hardware

- ❖Lighter / More Power / Faster Charging Battery Technology
- ❖Lightweight Single man Oxygen Generation
- ❖Sensor / Hardware Interoperability
- ❖Hypoxia monitoring / Prediction / Resilience to extreme environments

Telemedicine issues

- ❖Data prioritization / Metering
- ❖Bi-directional Communications
- ❖Cybersecurity – Protection from nefarious acts
- ❖Big Data Presentation – Easily Understood

Questions??