# Warrior Web – Program Introduction

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# Background

Energy harvesting combat boot, 2010-2011

Powered prosthetics with regenerative kinetics, 2007-2010

West Point Exoskeleton, 2011

# Warrior Web Program Elements

### Overview

Warrior Web seeks to develop an adaptive, compliant, nearly transparent, quasi-passive joint support system to mitigate musculoskeletal injury caused by dynamic events while maintaining soldier performance.

### Status

**Current BAA: Warrior Web Alpha**
Solicits the technology development portion of the Warrior Web program.

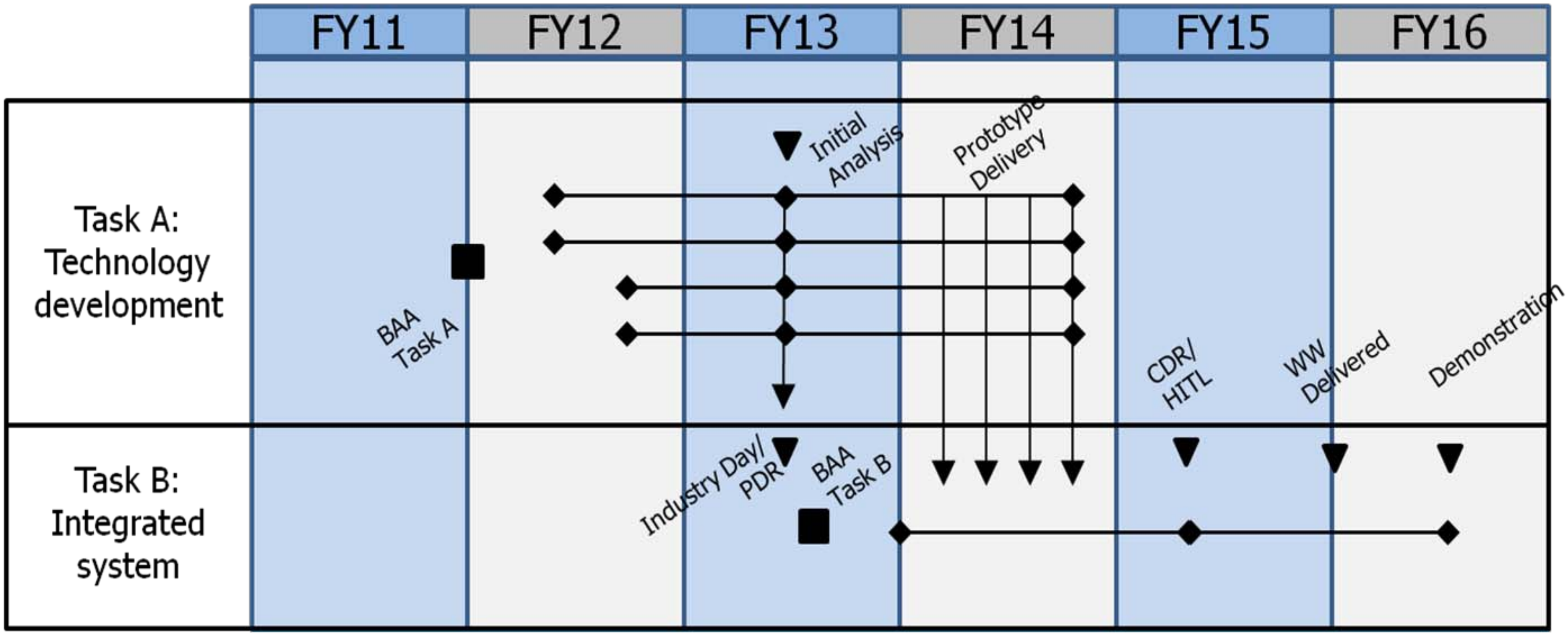
### Desired Specifications (from BAA)

- Mitigate injury
- Integrated suit total weight of no more than 9 kg
- Require no more than 100 W of continuous electric power
- Carry a 45 kg load, 80 kg soldier, at 1.25 m/s, level ground, while reducing relative metabolic cost by 25%
- No more than 4.5 kg of SOA soldier battery technology provides the power and stored energy necessary for a typical 24 hour mission without a charge.
- Protect human performance
- Basis for human-machine synergy

### Vision

- Human:
  - Skeletal Loading
  - Control
- Machine:
  - Augment muscle work
  - Store/regenerate energy
  - Assist kinematics and dynamics
  - Protect ligaments/tendons

# Warrior Web Program Schedule



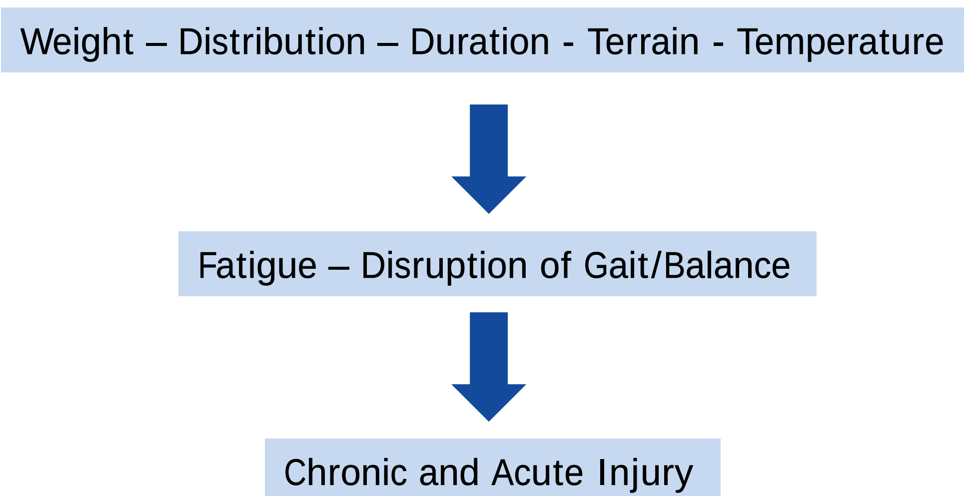
# Warrior Web Technical Thrusts

## Five Thrust Areas

- **Core Injury Mitigation Technologies**
  - Hardware and analytical solutions that significantly reduce injury to a wearer under typical warfighter mission profile situations.
- **Comprehensive Analytical Representations**
  - Accurate modeling that allows the integration of both passive and closed loop controlled active components with a full human biomechanical model.
- **Regenerative Kinetics**
  - Active and passive technologies connected to the human to provide highly efficient actuation.
- **Adaptive Sensing and Control**
  - Localized component and centralized suit sensing and control strategies that allow for applying injury mitigation techniques without adding metabolic cost to the wearer.
- **Suit Human-to-Machine Interface**
  - Research in materials, fabrics, structures, and human factors to account for the need of a conformal yet contributing Warrior Web suit and all associated practicalities.

# Technical Thrust : Injury Mitigation

**Hardware and analytical solutions that significantly reduce injury to a wearer under typical warfighter mission profile situations.**




**Possible approaches:**

- Mechanically/structurally create functionally stable positions under typical locomotion
- Managing load distribution and dynamic impact
- Reducing fatigue
  - Reducing metabolic cost to working muscles
  - Thermal technologies to reduce fatigue associated with high temperature missions
  - Enhancing blood flow to working muscles
- Maintenance of form in motion (running gait, jumping form, etc.) to reduce injury.
- Enhancing proprioception with increased carry load and fatiguing workload.
  - “Smart” bracing to enhance sensation of joint displacement and increase responsiveness to correction prior to injury.
  - Enhancing proprioception and tactile sensation through use of electrical noise stimulation.

# Technical Thrust : Sensing and Control

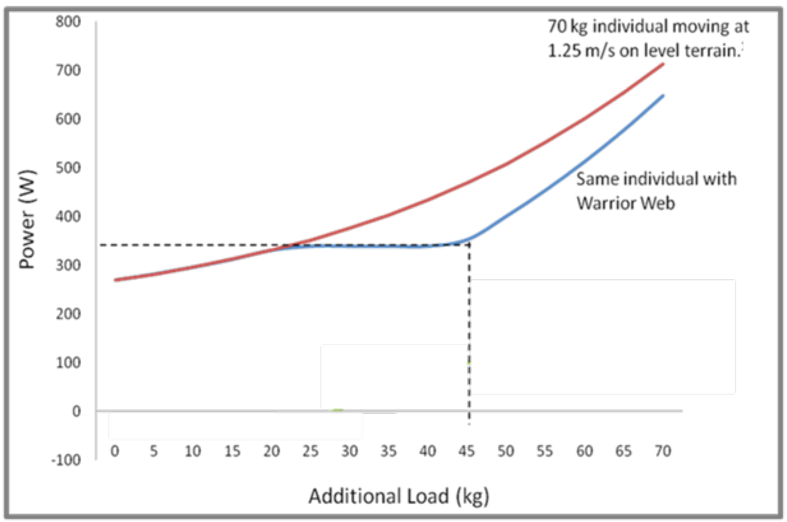
**Localized component and centralized suit sensing and control strategies that allow for applying injury mitigation techniques without adding metabolic cost to the wearer.**

**Contributing concepts:**

- Mechanical sensors
- Simple, continuous, and robust control
- Haptic stimuli for user awareness
- Control parameters tunable by the user
- Minimal cognitive load
- No metabolic load
- Physical compliance
- Inherent safety of the wearer
- Hardware and software safe failure modes

# Technical Thrust : Analytical Representations

**Accurate modeling that allows the integration of both passive and closed loop controlled active components with a full human biomechanical model.**




Basic example : Pandolf

**Inputs:**

- Mission environment (terrain)
- Representations of engineered technology (components, interfaces, closed loop realtime control, etc.)
- Dynamics of a scenario
- Accounting for soldier load and its modeled variations
- Soldier characteristics

**Outputs:**

- Injury risk and musculoskeletal analysis
- Energetics (metabolic cost)
- Mechanics

# Technical Thrust : Human-to-Machine Interface

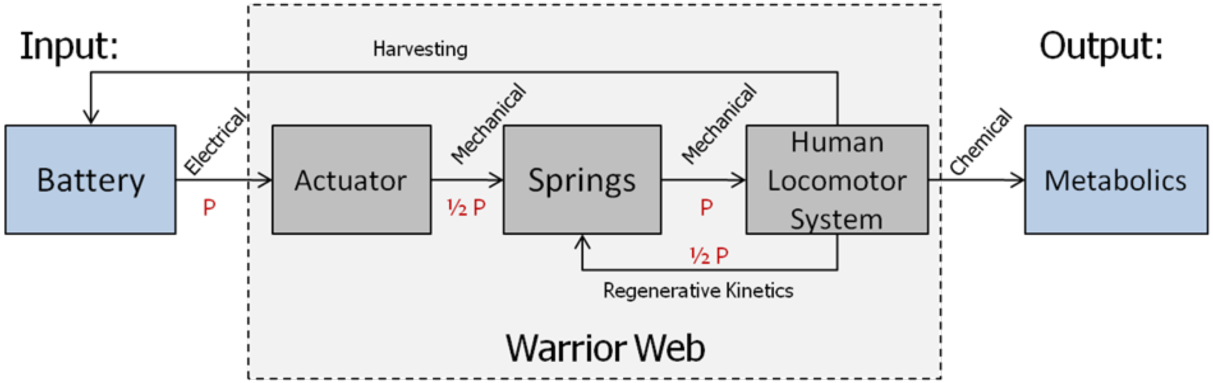
**Research in materials, fabrics, structures, and human factors to account for the need of a conformal yet contributing Warrior Web suit and all associated practicalities.**

**Examples of focus areas:**

- Thermal regulation (primarily using passive methods)
- Moisture control
- Interface to joints and skin without irritation
- Incorporates active and passive devices (e.g. attached springs) while allows for the integration of novel actuation and injury mitigation potential hard points
- Fabric material considerations
- Physiological considerations of suit parameters to aid performance (e.g. compression and banding of muscle)
- Capable of load distribution while maintaining structure and being lightweight
- Ability to safely incorporate electrical system and operate at appropriate power levels
- Can be extended to the entire body
- Assessment through the application of ergonomics and engineering psychology

# Technical Thrust : Regenerative Kinetics

Active and passive technologies connected to the human to provide highly efficient actuation.




**Examples:**

- Energy efficient actuation delivers half the required power to the joints to reduce metabolics.
- Negative work in gait is stored as elastic energy in springs and released to assist locomotion.
- Limited braking power is harvested.

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