# Modeling the Response to Blast-Induced Accelerative Loading

S&T Campaign: Sciences for Lethality & Protection
*Battlefield Injury Mechanisms*

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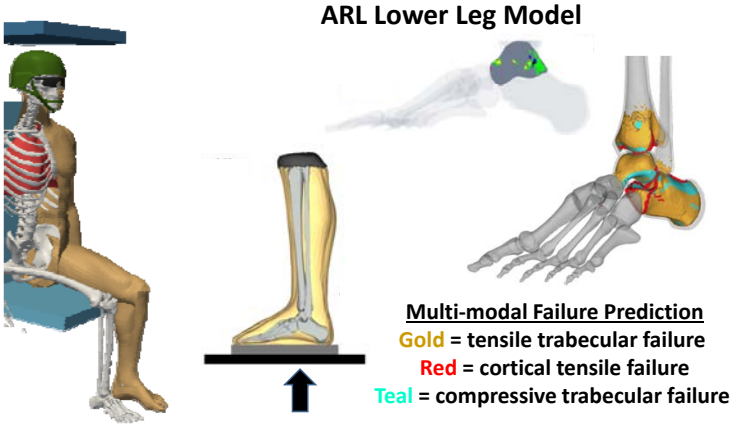
## Research Objective

- Develop detailed multi-scale computational models of the human anatomy to better understand mechanisms and thresholds of injury.
- Simulate human response to blast loading and evaluate the effectiveness of existing and prototype protective technologies.

### ARL Lower Leg Model



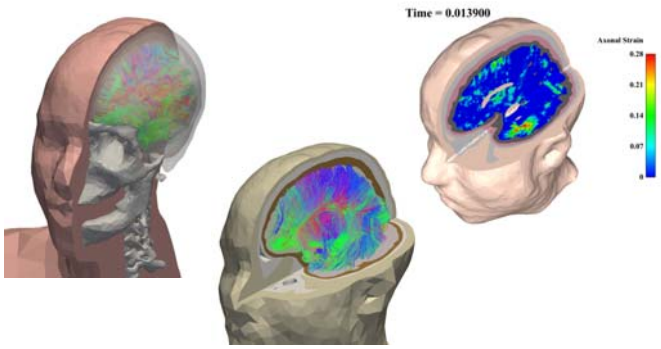
**Multi-modal Failure Prediction**
Gold = tensile trabecular failure
Red = cortical tensile failure
Teal = compressive trabecular failure

*Foot/ankle fracture prediction during an underbody blast event.*

## ARL Facilities and Capabilities Available to Support Collaborative Research

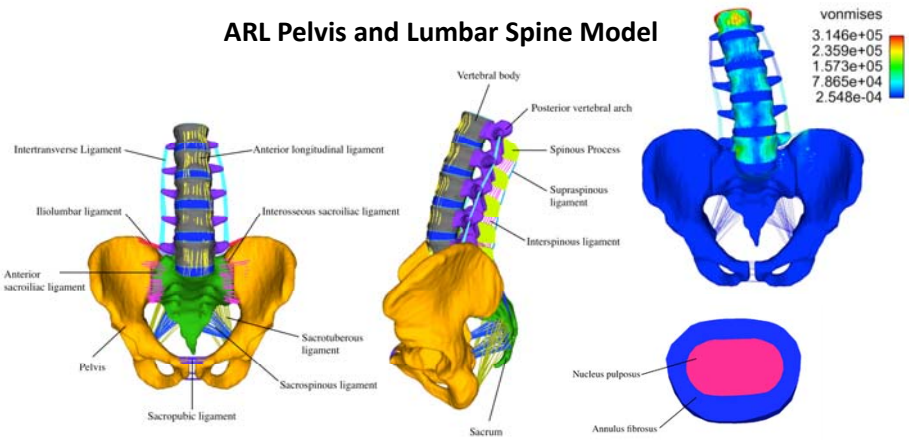
- In-house expertise in biomechanics, constitutive model formulation, and high-rate testing.
- Access to suite of DOD, DOE, and COTS software running on multiple high performance computing platforms.
- Unique blast and ballistic test capabilities for model development and validation.

### ARL Head/Brain Model




*Modeling of neural pathways helps link computational mechanics and neuroscience.*

### ARL Pelvis and Lumbar Spine Model




*Detailed lumbar spine anatomy with biomechanically relevant ligaments and bi-phasic disc representation.*

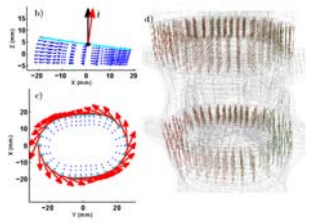
Cauchy stress of transversely isotropic elastic constitutive model with two fiber families ***a*** and ***g***

$$T = \kappa \ln J I + \frac{2}{J}\mathrm{dev}\left[\left(C_{10} + \bar{I}_1 C_{01}\right)\bar{B} - C_{01}\bar{B}^2 + \mathcal{F}(\bar{I}_4)\bar{A} + \mathcal{F}(\bar{I}_6)\bar{G}\right]$$

with $\bar{A} \equiv \bar{a} \otimes \bar{a}$, and $\bar{G} \equiv \bar{g} \otimes \bar{g}$.

Collagen fiber response function:

$$\mathcal{F} \equiv C_i\left(\exp\left[\beta_i(I-1)\right] - 1\right)$$



*Constitutive model formulation for biological tissues.*

## Challenges

- On-going challenge to bridge the gap between mechanical and physiological responses.
- Limited biomechanical data available at appropriate loading rates and scales for model validation.
- Material characterization for complex biological tissues.

## Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Biomechanics research facility with experience in high-rate testing of biological tissues.
- Knowledge and expertise to help better understand the effects of mechanical loading on human physiology and clinical outcome.

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