Modeling the Response to Blast-Induced Accelerative Loading

S&T Campaign: Sciences for Lethality and Protection
Kinetic Protection
Soldier Protection

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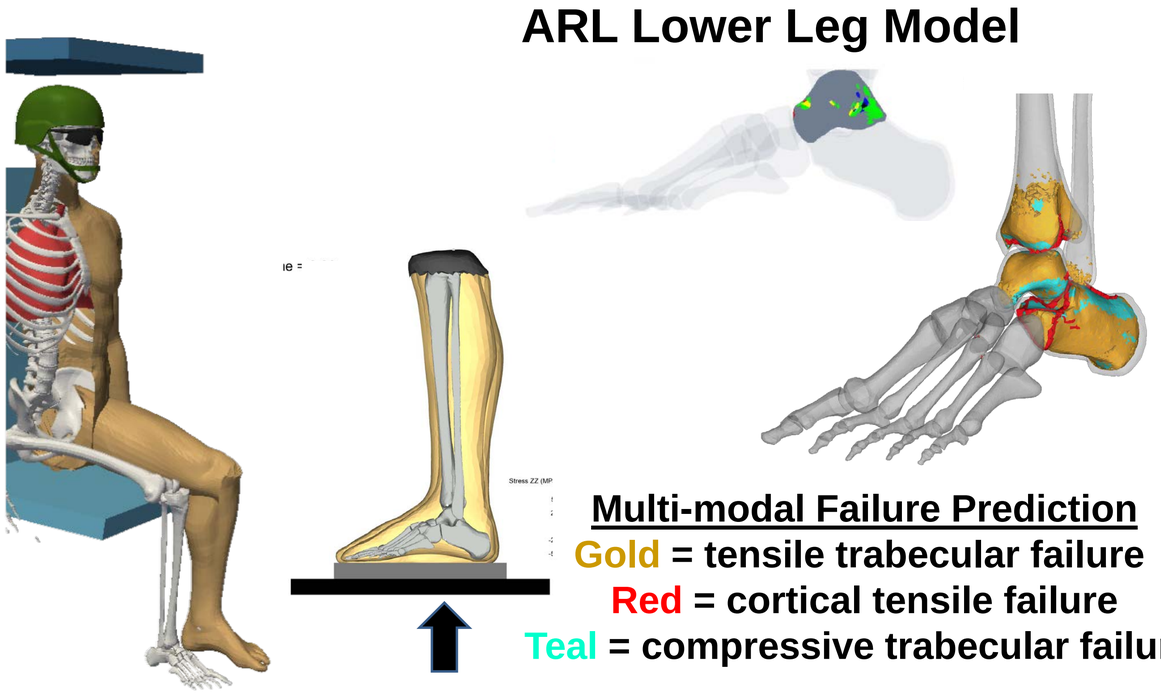
Research Objective

- **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 Facilities and Capabilities Available to Support Collaborative Research

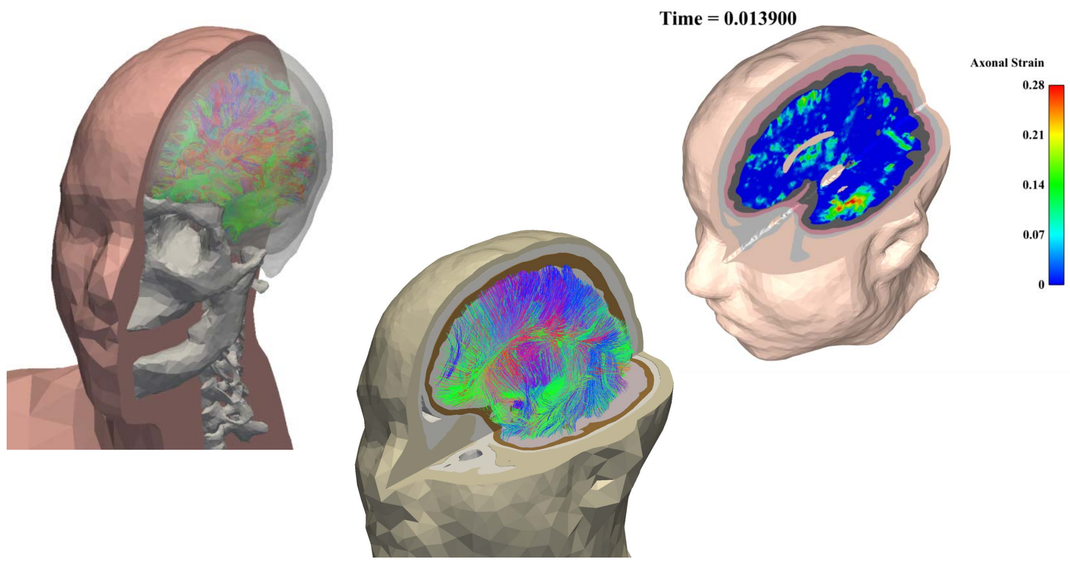
- **In-house expertise in biomechanics, constitutive model formulation, and high-rate testing**
- **Access to suite of DOD, DOE, and commercial software running on multiple high-performance computing platforms**
- **Unique blast and ballistic test capabilities for model development and validation**

ARL Lower Leg Model



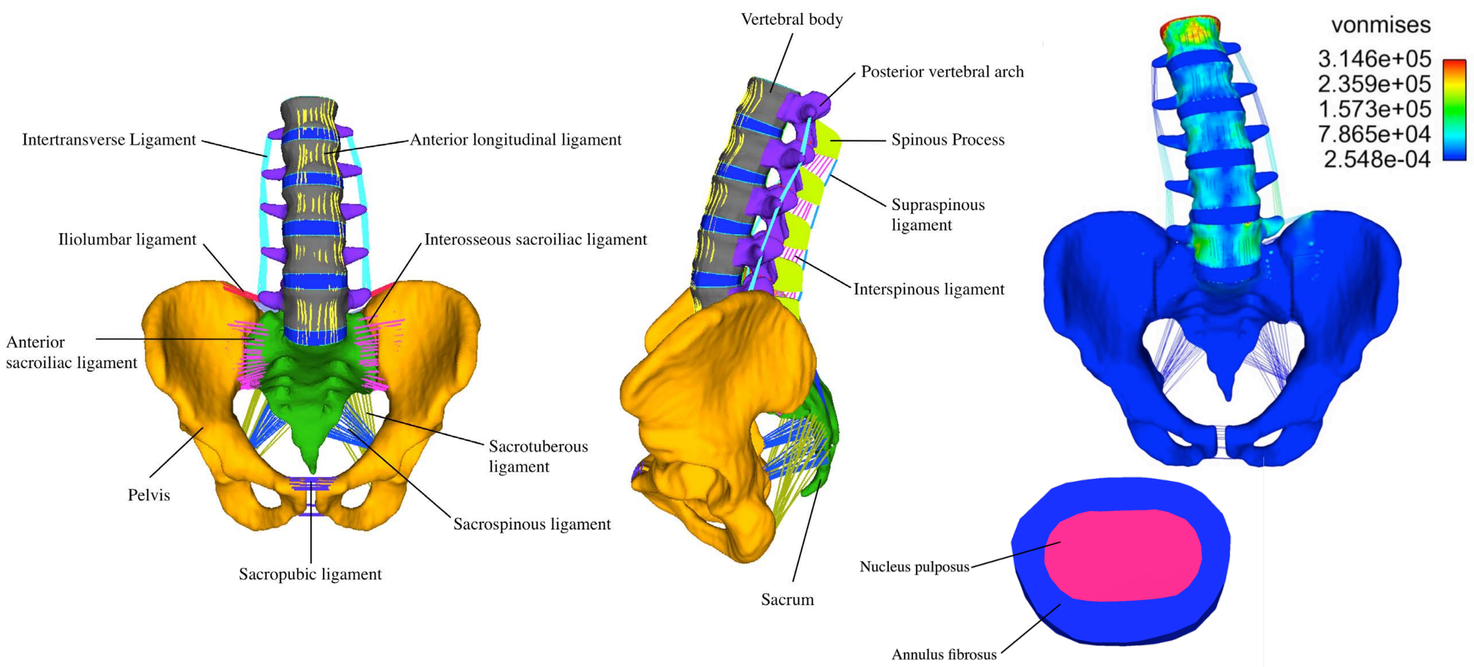
Foot/ankle fracture prediction during an underbody blast event.

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.

Constitutive Modeling

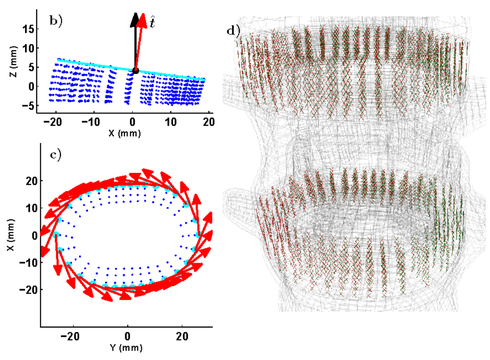
Cauchy stress of transversely isotropic elastic constitutive model with two fiber families ***a*** and ***g***

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

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

Collagen fiber response function:

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



Fiber reinforced 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**