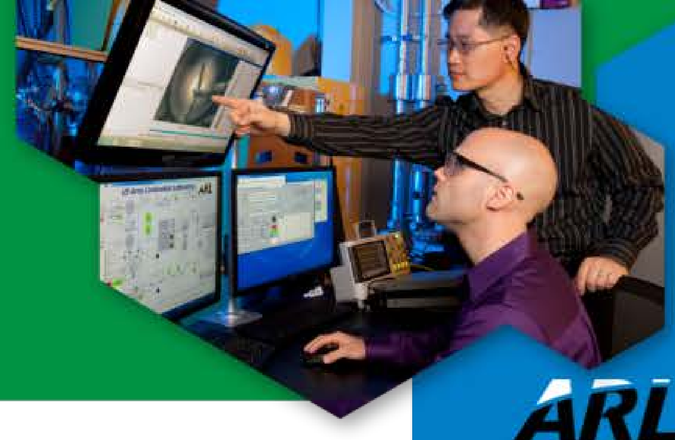
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

Modeling the Response of the Brain to Ballistic Loading

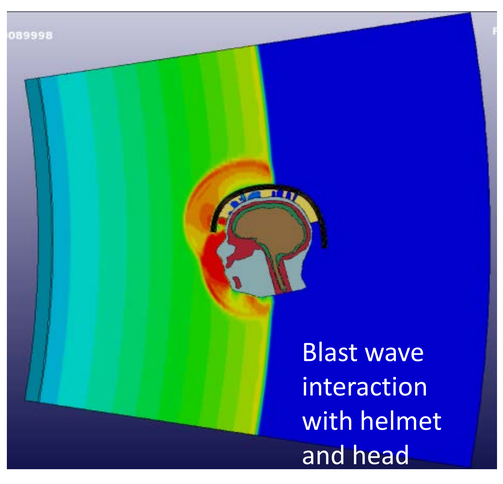


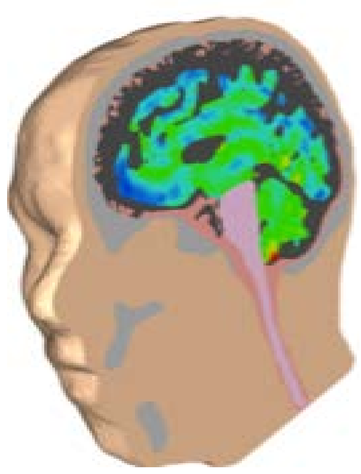
S&T Campaign: Sciences for Lethality & Protection
Humans in Extreme Environments

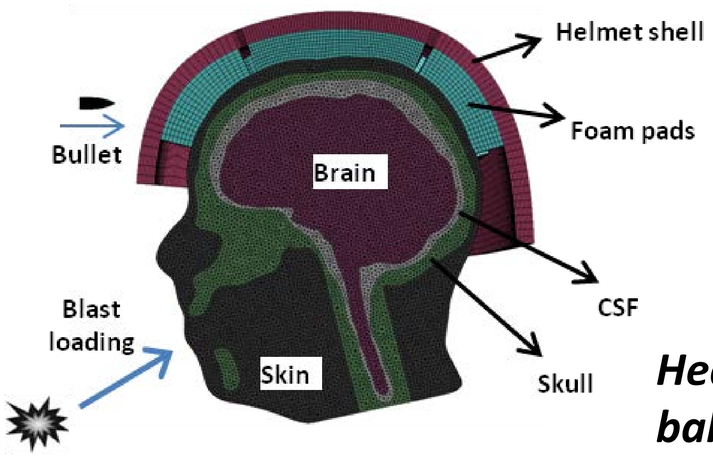
Dr. Sikhanda Satapathy, (410) 278-8565
Email: sikhanda.s.satapathy.civ@mail.mil

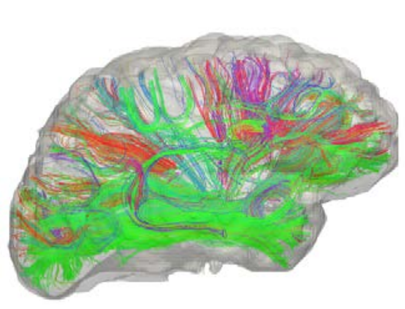
Research Objective

- Understand loading mechanisms leading to brain injury
  - Transmission of blast and ballistic loads through helmet and pad system to the head and brain.
  - Relate transmitted load to injury mechanisms
- Evaluate and improve head protection systems
  - Optimized composite shell
  - Novel pad systems





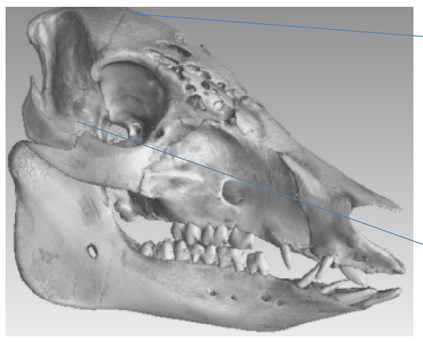


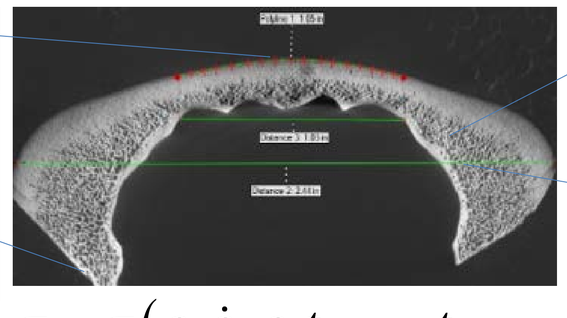


Head-Helmet model to assess ballistic load transfer to brain and consequent injury

Challenges

- Accurate material models for composite shell, polymeric pad, skull and brain tissues
- Experimental data on surrogate systems (animal models, cadaveric subjects and instrumented head-forms)
- Transfer functions that relate surrogate systems to human model
- Injury criteria and threshold for soft and hard tissues
- Biofidelic models and convergent numerical methods



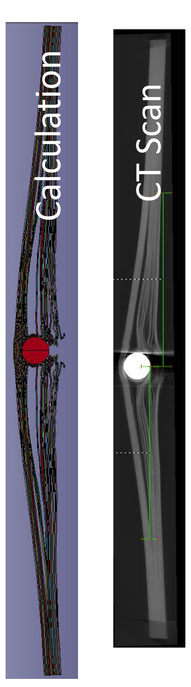


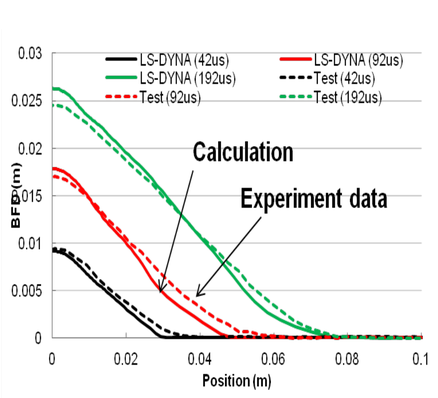
$$\sigma = \sigma\left(\varepsilon, \dot{\varepsilon}, \rho, t_{cortical}, t_{trabecular}, \text{topology}\right)$$

Multi-scale tissue model development using porcine skull as surrogate

ARL Facilities and Capabilities Available to Support Collaborative Research

- Expertise in biomechanics, constitutive model formulation, numerical analysis and high rate experiments.
- Computational Modeling and Simulation
  - Segmentation of MRI/ CT images
  - Biofidelic model generation
  - Parallel Lagrangian and Eulerian hydrocodes
- Ballistic rate experimental facilities
  - Ballistic ranges for characterizing V50 and BFD
  - Gas guns for shock experiments, Split Hopkinson Pressure Bars and Load cells for low rate characterization
  - micro-CT, high speed cameras, Photonic Doppler Velocimetry, VISAR





psf	V_{50} difference
1.6	2%
1.8	7%
2.2	5%

Simulations of ballistic experiment captures ballistic limit, Back face deformation and delamination of UHMWPE composite.

Shock Experiment Facility

SHPB Experiment Facility

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Tissue injury criteria and threshold for hard and soft tissues.
- Biofidelic computational models with relevant topology and finite element discretization.
- Accurate numerical tools for fluid-structure interaction and damage analysis.
- Multi-scale, multi-physics models for injury biomechanics.
- Biomechanics research to establish transfer function between surrogate models and human.

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED