Z. Li, X. Zhang and S. Ghosh (JHU); C. Meyer, J. Yu and D. O’Brien (ARL); E. Bonyi and K. Aslan (MSU); B. Haque and J. Gillespie (UDel)

How We Fit

Materials-by-Design Process
- Develop a computationally efficient multi-scale damage model to be used for modeling macro-scale composite structures
- Design experiments to elicit relevant damage modes

Mechanism-based Approach
- Impact response of composite materials is complex and dependent on details of damage evolution at meso-, micro-, and nanoscales.
- Simulating and optimizing composite structure performance requires efficient micro-level computational tools that can be validated by experiment.
- Identify key damage mechanisms in composite impact
- Optimize high strain rate performance through multiscale structure design.

Technical Approach

- Identification of Damage Mechanism
- PHCD Model
- Microscale Model
- Macroscale Model
- Multi-scale Damage Model of Composites
- Homogenization

Key Accomplishments

- Developed framework for predicting high-rate, continuum-scale material parameters, connecting microscale to continuum to enable materials by design of composite materials
- Enabled simulation of high-rate response of large scale composite structures, accounting for critical subscale behavior

Future Directions

- Develop meso-mechanical FE models of plain-weave composites considering UD Tows, tow-tow debonding, & interstitial matrix
- Predict Key damage mechanisms identified in canonical perforation experiments
- Incorporate evolving length scales into PHCD Model to account for diffuse/local damage
- Predict input parameters for high rate, progressive damage codes (LS-Dyna) used in structural design
- Integrate with cross-cutting hierarchical multiscale simulations

Impact

- Framework for materials-by-design for composite materials under high rate loading
- Models and simulations will increase understanding of how particular local damage mechanisms affect global response.
- The tools developed here will lead to improved protection materials and structures while decreasing the cost and time for development.