How We Fit

- Conducting high rate punch shear experiments to understand the energy dissipating damage mechanisms as a function of rate of loading
- Developing micro-scale punch shear test models to understand the evolution of damage mechanisms leading to model based prediction of material properties
- Structural scale punch shear damage mechanisms
- Mesoscale fracture of fiber bundles, fragment lengths, & transverse tow cracks
- Microscale fiber fracture, interface debonding, and matrix cracking

Technical Approach

- Micromechanical modeling of Punch & Crush considering such Effects, Fiber-Fracture, F-M Debonding, & Matrix Plasticity
- Prediction of MAT162 Input Properties
  2. Elastic-Plastic Matrix Deformation from Experiments

Key Accomplishments

- Infusion of UD tows with 7 TT fibers into Ribbon
- Quasi-static punch shear testing of UD ribbons
- New concepts for PST Experiments
- 2D Pain-Strain FEM of 6 Fibers and 7 Resin Blocks with CZM fractures of Fiber-Fiber & Fiber-Matrix Interfaces
- Numerical Simulations of Punch Shear and Punch Crush
- Identification of Key Damage Mechanisms of Punch Shear and Crush

Future Directions in 2017

- Dynamic punch shear experiments will be conducted on UD ribbon specimens
- 3D solid model with CZM fiber fracture and fiber-matrix debonding will be developed to study the 3D damage mechanism under high strain rate loading

Key Goals

- Long Term Research Goals:
  - Predict the PUNCH SHEAR Damage Mechanisms of Uni-Directional Composites found in ARL Canonical Perforation Experiments
  - Micro-Mechanical Mechanisms of Progressive Punch Shear Damage
  - Tension-Shear Fiber Fracture
  - Mixed-Mode Debonding of Fiber-Matrix Interphase
  - Large Non-Linear Deformation of Matrix Resin
  - Predict MAT162 Punch-Shear Parameters Capturing all Micro-Mechanical Developed Direct-Impact Punch-Shear Tests (DI-PST) Modes described above
  - Under Dynamic Loading Conditions using Developed Direct-Impact Punch-Shear Tests (DI-PST)

Micromechanical Modeling of 2D Punch-SHEAR & Punch-CRUSH

- Punch-SHEAR
  - Punch shear damage occurs in a shear-cone under the punch
  - Transverse fiber fracture occurs under mixed mode loading
  - Peak punch force occurs before any visible crack opening

- Punch-CRUSH
  - Identical punch shear damage occurs before the punch crush damage
  - Transverse fiber fracture leads to fiber crush with large deformation around the punch periphery
  - Debonding and pull out mechanisms appear at large deformation

Impact

- Provide fundamental understanding of punch-shear and punch-crush damage mechanisms under dynamic loading conditions
- Predict the MAT162/ARL-CDM-UMAT punch-shear/crush modeling parameters (SFS, AM2, AM4, C3, C5, EEPXN, SFC, ECRS)
- Direct impact punch-shear and crush experiments at mm-length scale will provide model-validating rate-dependent data
- Predict computational damage surfaces under HSR multi-axial dynamic loading conditions for which experiments are difficult
- Properties predicted at micromechanical length scale can then be used to model continuum damage mechanics models.