The development of controlled microstructures is a primary goal in designing novel materials with unique properties. The main mission of the Center for Shock Wave-processing of Advanced Reactive Materials (C-SWARM) is to predict shock conditions under which new materials can be synthesized. This processing generates high temperatures and pressures that can lead to new materials being created. Such material transformations are governed by a plethora of physics, mechanics, and chemistry that test our understanding of microstructure-property-relations and our capacity to tune materials at will. The goal of C-SWARM is the deployment of verified and validated computational simulations to predict the properties and dynamics of this complex system, with quantified uncertainty.