# 1 Executive Summary

The scientific and technological needs of the U. S. Department of Energy posed by the Accelerated Strategic Computing Initiative/Academic Strategic Alliances Program (ASCI/ASAP) encouraged the University of Illinois at Urbana-Champaign (UIUC) to establish the Center for Simulation of Advanced Rockets (CSAR) in September 1997. The outstanding quality of the faculty and staff, facilities, and research infrastructure offered by UIUC have enabled a unique partnership among university researchers and the DOE Defense Program laboratories to advance the state of the art in computational simulation of complex systems. State, regional, and university resources are also supporting the program, and an experienced research team is fulfilling the mission of the Center.

The goal of CSAR is the detailed, whole-system simulation of solid propellant rockets from first principles under both normal and abnormal operating conditions. The design of solid propellant rockets is a sophisticated technological problem requiring expertise in diverse subdisciplines, including the ignition and combustion of composite energetic materials; the solid mechanics of the propellant, case, insulation, and nozzle; the fluid dynamics of the interior flow and exhaust plume; the aging and damage of components; and the analysis of various potential failure modes. These problems are characterized by very high energy densities, extremely diverse length and time scales, complex interfaces, and reactive, turbulent, and multiphase flows.

CSAR is focusing on the reusable solid rocket motor (RSRM) of the NASA Space Transportation System, better known as the Space Shuttle, as its long-term simulation vehicle. The RSRM is a well-established commercial rocket, is globally recognized, and most importantly, design data and propellant configurations are available. During the first year of the research program, we completed a simplified version of an integrated rocket simulation code that provided invaluable experience in system integration (GEN0). At the end of the fourth year of our ten-year program, the implementation of a fully integrated simulation code (GEN1) is complete. It provides a characterization of various burn scenarios and the onset of potential component failures. Other sub-scale rockets are simulated to provide verification data for CSAR codes. Refined multiscale component models and advanced system integration concepts based on lessons learned from GEN1 constitute the key features in the second-generation code (GEN2) under active development. The initial version of this code, GEN2V1.0, has been completed and exercised in solid propellant rocket simulations.

More than 120 UIUC faculty, students, and researchers contribute to the success of the Center. An External Advisory Board provides critical guidance in rocket simulation and computational science. The DOE-supplied budget has been sufficient to maintain an aggressive research program. In addition, the University of Illinois has provided funds for ancillary research expenditures, computer workstations, and facility renovation. Center personnel have traveled widely to explore rocket science and technology, identify technical collaborators, describe the ASCI/ASAP program, and establish relationships among Center investigators, DOE DP scientists, and industry leaders.