COMMENTS ON THE AIMS OF THE WORKSHOP

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The Defense Advanced Research Projects Agency (DARPA), in collaboration with the National Science Foundation (NSF), is pleased to sponsor this important workshop on the "Theoretical Foundation for Large-Scale Computations of Non-Linear Material Behavior." The research-support activities of both DARPA and NSF have long represented a significant commitment to the advance of science and technology. DARPA supports basic and applied research and development work in a wide range of technical areas for eventual application to problems related to the national defense. The NSF has an even broader charter in overseeing much fundamental research in many diverse fields of science and engineering. It seems most appropriate, therefore, that an academic setting has been selected for this forum, and we wish to thank our hosts and the supporting staff at Northwestern University for their hospitality and organizational efforts that have made this meeting possible.

One of the many areas of common interest to both DARPA and NSF, that of computer modeling of complex physical phenomena, includes the more specific subject of this workshop. This area has witnessed remarkable development over the past few decades, and both agencies are proud to have played important roles in marking that progress. We maintain a keen interest in supporting further advances: for DARPA, to improve and expand the capabilities of the cognizant research community to carry out detailed computations on problems of concern to the Department of Defense; for NSF, particularly from the perspective of its Division of Civil and Environmental Engineering, to develop an improved fundamental understanding of the response of soils and structures to dynamic loading. The DARPA and NSF interests are clearly complementary.

Problems addressed using large-scale computations that are of interest to DARPA and NSF are many and varied. Much of the early impetus for development of computer modeling as a research tool derived from the need to solve complex problems associated with the development of advanced weapons systems in the national defense laboratories. The list of defense-related applications has grown considerably over the years. Notable examples of such applications include:

1. analyses of structural impacts at very high velocities (e.g., meteorite impacts on satellites and other space structures, and impacts involving aircraft or interceptor rockets);
2. analyses involving blast loading and effects on soils or structures (e.g., as might be encountered in qualification tests for advanced rocket motors);

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(3) studies related to the design and evaluation of numerous conventional ordnance systems (e.g., chemical energy munitions, including shaped charges and explosively formed penetrators);

(4) analyses of penetrator/target interactions and advanced armor systems;

(5) examination of technical missile basing issues and site hardening for defense systems;

(6) combustion and explosion phenomena (e.g., deflagration-to-detonation transitions, and explosion initiation and growth);

(7) explosive welding, and, most recently, the dynamic compaction of materials.

Other applications for large-scale computations include calculations of strong ground motions resulting from earthquakes, and analyses of structures designed to withstand the resulting forces. For most of these problems, material properties and deformation/fracture behavior are of considerable importance, and successful modeling of a given problem is critically dependent on both our understanding of those properties and our ability to devise a reasonable physical model and the corresponding mathematical algorithms necessary for implementation in computer simulation programs.

Modeling of non-linear material behavior associated with stress waves in solids is the focal point for this workshop. A general assessment of the current state of this critical technical area was recently made by a panel of solid mechanics specialists, who worked with members of the scientific staff of the BDM Corporation, McLean, VA under DARPA sponsorship. Members of this panel include Professors Sia Nemat-Nasser of Northwestern University; G. A. Hegemier of the University of California, San Diego; and Robert J. Asaro of Brown University. These members were recently joined by Professor Thomas Hughes of Stanford University, an expert in the area of numerical implementation of constitutive models. All of these individuals are participants in this meeting. The panel was asked to review the general area of elasto-plastic and visco-plastic material descriptions and their implementation in large computer simulation programs. In addition, it was requested that the current extent of communication and collaboration between the solid mechanics and numerical analysis communities be considered and recommendations made for enhancing our overall capabilities in large-scale computational solid mechanics, particularly for defense-related problems.

The initial work of the panel is described in a recent report issued by the BDM Corporation ("Report and Recommendations for Improving Constitutive Relations Used in Computer Codes," S. Nemat-Nasser, G. A. Hegemier, and R. J. Asaro, Report BDM/W-83–44–TR, The BDM Corporation, McLean, VA, July 15, 1983). One specific recommendation contained in that report is that, "as a first step toward cultivating productive exchange and collaboration between concerned groups," a workshop be held in the fall of 1983 at which prominent solid mechanics researchers and developers and users of computer simulation programs are brought together to discuss critical material modeling issues and exchange views on perceived problems of immediate concern. This meeting represents the action taken in response to that recommendation. The work of the panel is expected to continue, however, and another recommendation suggests broader and more intensive future activities. A concerted effort will be made to assemble relevant known results involving constitutive relations for metals, certain engineered materials, and geo-materials, and to present these results in a unified format that includes discussion of their range of applicability—but also their