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# **The US Army Research Program in Propulsion and Energetics**

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Currently, the Army's mechanics research program is executed by the Army Research Office, the Army Research Laboratory, four Research, Development and Engineering Centers, and the Corps of Engineers. In order to jointly develop the Army's mechanics basic research agenda for the future, a Mechanics Research Strategy Planning Workshop was convened on 17-18 January 2001 with participants from all the pertinent Army agencies. The report from that meeting is still in the draft form. However, in the interest of providing the attendees at this ARO-AFOSR Contractors Meeting in Chemical Propulsion with the vision of the participants at the planning meeting, I have copied below the introduction from the propulsion and energetics section of that report. In my presentation, I will highlight some of the aspects of the report.

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**U.S. ARMY  
MECHANICS RESEARCH STRATEGY  
PLANNING WORKSHOP  
17-18 JANUARY 2001  
DUCK, NORTH CAROLINA**

## **PROPULSION AND ENERGETICS**

### **Introduction**

Propulsion and energetics research supports the Army's need for higher performance propulsion systems. These systems must also provide reduced logistics burden (lower fuel/propellant usage) and longer life than today's systems. Fundamental to this area are the extraction of stored, chemical energy and the conversion of that energy into useful work, for vehicle and projectile propulsion. In view of the high temperature and pressure environments encountered in these combustion systems, it is important to advance current understanding of fundamental processes as well as to advance the ability to make accurate, detailed measurements for the understanding of the dominant physical processes and the validation of predictive models. Thus, research in this area is characterized by a focus on high pressure, high temperature combustion processes and on the peculiarities of combustion behavior in systems of Army interest.

Current ground and air vehicle propulsion relies on reciprocating (Diesel) and gas turbine engines. These engines must be capable of delivering high power with high fuel efficiency. These thrusts, power density and efficiency, are the heart of the Army's initiative for the Future Combat System. The development of reliable, predictive models for vehicle engines will require advances in understanding fundamental processes, such as turbulent flame structure, heat transfer, and chemical kinetics, as well as understanding and control of the complex chain of fuel injection-atomization-ignition-combustion processes. An additional complication is presented by the high

pressure/temperature environment, encountered in Diesel engines, which influences liquid behavior and combustion processes at near-critical and super-critical conditions. It should be noted that over 95% of Army vehicles are diesel-powered and that the Army desires the capability to use a single, logistics fuel in all engines, both diesel and turbine.

Gun and missile propulsion relies on the rapid, controlled release of energy from high energy density propellants, which exhibit unique combustion characteristics. Modern composite, solid propellants are characterized by a complex, multi dimensional flame structure, with solid, liquid, liquid-gas, and gas phase reaction zones. The small scales of the combustion zones, typically on the order of microns, and the high pressures, up to 100,000 psi, present formidable challenges for combustion diagnostics. There are systems whose future development requires new directions in combustion research. Among these is the electrothermal-chemical (ETC) gun, in which the ignition, and potentially combustion control, of solid propellant is achieved by high temperature plasmas. Concepts for advanced, variable thrust missile propulsion also pose difficult challenges, e.g. the interaction/combustion of hypergolic propellants, the development of novel combustion chambers (c.f. vortex combustors), the dynamics of pintle nozzles, etc. An underlying concern with all high energy density systems is the hazard and system vulnerability posed by the propellant. Thus, research is also needed to determine the response of these materials to inadvertent ignition stimuli and factors controlling undesired combustion behavior, such as pressure oscillations. A key goal is the coupled analysis of propellant composition, material characterization, combustion dynamics, and sensitivity.