Memorandum: to Pat Nolan, Tim Cowles, Carl Alexander

Shock tube research for Theater Missile Defense at the University of Minnesota

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A dedicated shock tube with a Mach 8 capability, together with instrumentation (high speed camera; particle fluid holography system) for monitoring the aerodynamic breakup of all kinds of simulants, has been constructed with Army ($160,000) and leveraged NSF ($130,000) funds. The shock tube and high speed camera are now operational, and the particle field holography system is being assembled.

The parameters controlling the breakup and the resulting drop size distribution in fragmented clouds arising from aerodynamic breakup of simulants at high speeds have not been identified.

The size distributions of thickened simulants of the same viscosity at the same dynamic pressure are greatly different (for example, see the works of Jim Soltisz at SAIC) but the reason why is not known. This also leaves us at risk with regard to new agents for which simulants have not been tested.

The controlling parameters are surely associated with the fluid's rheology, measures like relaxation times and solvent quality, which are outside the circle of expert knowledge of other teams. To come up with the right parameters we need good ideas and the capability of generating supporting data in reasonable times at reasonable costs.

The shock tube is dedicated to the study of aerodynamic breakup at high air speeds of all kinds of materials, organic and polymeric liquids, seeded liquids (e.g. imbiber beads) and even compacted granular material.

The first goal of our shock tube research is to perfect methods to determine the drop size distribution, particularly the fraction in large drops and the fraction in vapor and mist, in the fragmented cloud after breakup.

These data can then be used as input in the post engagement ground effect model.

Shock tube research is many orders of magnitude less expensive than reverse ballistic, sled and field tests previously used by the Army to get drop size distributions.

The entire range of conditions encountered in missile defense can be simulated in our shock tube (see appendix).

The procedures of testing and data acquisition are so much easier (and cheaper) in the shock tube that it is possible to generate very extensive data bases for the interrogation of the parameters controlling the breakup of all kinds of simulants, of present interest and future unknown threats.

Scale-up effects correlating size distributions after breakup with the initial size of the liquid mass can be carried out systematically in the shock tube because the initial size of the parent drop can be systematically varied. A high speed (200,000 frames/sec), high resolution drum camera was put in place last week and is being used to record the sequence of events from the initial to final breakup of a liquid mass (20 to 1000μs). Our first photographs of the breakup of a water drop at Mach 3 are included in this memorandum; the quality of the photographs will be greatly increased in the future runs. The objective of the first test was primarily to check the synchronization of the shock tube and camera timing systems. The resolution of the camera is sufficiently refined that details of the breakup process can be examined. Estimates of drop size distributions will be obtained using the particle field holography system. This will also allow us to check scale effects by comparison with data from equivalent reverse ballistic tests.