WATER AND SOFT-SOIL IMPACT TESTING AND SIMULATION

Edwin L. Fasanella[a] and **Karen E. Jackson**[b]

[a]US Army Research Laboratory, Vehicle Technology Directorate
NASA Langley Research Center
Hampton, VA 23681-0001
e.l.fasanella@larc.nasa.gov

[b]US Army Research Laboratory, Vehicle Technology Directorate
NASA Langley Research Center
Hampton, VA 23681-0001
k.e.jackson@larc.nasa.gov

Water impact tests of simulated spacecraft capsules were performed at NASA Langley in the 1950's to determine the impact accelerations that an astronaut might experience on return from Earth orbit [1]. In the 1990's, NASA Langley was responsible for advanced technology development for a proposed Mars sample return program in which Mars rock and soil samples would be returned to Earth for analysis. These sample return missions required the design of reliable Earth entry vehicles. Instead of water impact, these missions were designed for impacts onto soft-soil. Since the reliability of parachutes is less than the desired reliability for containment, the Earth entry vehicle was to be designed for an earth impact at terminal velocity. Multiple drop tests of instrumented hemispheres were performed onto soft-soil for impact velocities from a few feet per second to over 100 miles per hour. Later, the same hemispheres were dropped into water and correlated with finite element models in preparation for a more complex water drop test. The finite element model development and correlation between these drop tests and the analytical predictions will be presented.

In March 2002, a 25-ft/s vertical drop test of a composite fuselage section was conducted onto water. The purpose of the test was to obtain experimental data characterizing the structural response of the fuselage section during water impact for comparison with two previous drop tests that were performed onto a rigid surface and soft soil. For the drop test, the fuselage section was configured with ten 100-lb. lead masses, five per side, that were attached to seat rails mounted to the floor. The fuselage section was raised to a height of 10-ft. and dropped vertically into a 15-ft. diameter pool filled to a depth of 3.5-ft. with water. Approximately 70 channels of data were collected during the drop test at a 10-kHz sampling rate. The test data were used to validate crash simulations of the water impact [3] that were developed using the commercial nonlinear, explicit transient dynamic codes LS-DYNA and MSC.Dytran. The fuselage structure is modeled using shell and solid elements with a Lagrangian mesh and the water is modeled with both Eulerian and Lagrangian techniques. The fluid-structure interactions are executed using the "fast" general coupling in MSC.Dytran and the Arbitrary Lagrange-Euler (ALE) coupling in LS-DYNA. The correlation and validation of the models will be presented. Also, the influence of changes in mesh density, mesh uniformity, fluid viscosity, and failure strain will be discussed.

References

[1] Victor L. Vaughan, Jr., "Water-Landing Impact Accelerations for Three Models of Reentry Capsules," National Aeronautics and Space Administration, Washington, DC, Technical Note D-145, October 1959.

[2] E.L. Fasanella, Y. Jones, N. F. Knight, Jr., S. Kellas, "Earth Impact Studies for Mars Sample Return," *Journal of Spacecraft and Rockets*, v.39, no. 2, pp 237-243, 2002.

[3] Edwin L. Fasanella and Karen E. Jackson, "Water Impact Test and Simulation of a Composite Energy Absorbing Fuselage Section," Proceedings of the American Helicopter Society 59th Annual Forum, Phoenix, AZ, May 6-8, 2003.