

Visitor Research Report

Visitor Name: Professor Ernie Heysfield
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Area of Research: Soil Characterization for Orion
Contingency Land Landings

Period of Visit: May 12, 2008 through August 15, 2008

Goal:

Characterize Soil to Develop Computer Simulations for Modeling Ground Landings of the Orion Space Capsule.

Experimental work is being conducted at the National Aeronautics and Space Administration's (NASA) Langley Research Center (LaRC) to investigate ground-landing capabilities of the Orion crew exploration vehicle (CEV). The Orion capsule will service the International Space Station and be used for future space missions to the Moon and to Mars. A series of capsule impact tests are being performed at the NASA Langley Landing and Impact Research Facility (LandIR) to evaluate ground landing feasibility of the Orion space capsule. During the June 07 through October 07 time period, twenty-one swing tests were conducted using the LandIR gantry to evaluate Orion's ground landing impact response. Currently, vertical drop tests are being conducted at the NASA Langley 70-ft vertical drop test facility to attain additional capsule-soil impact information.

Strategy:

The experimental results derived from the swing tests and vertical drop tests provide data for validating and calibrating nonlinear dynamic finite element models, which were developed during this study. Because of the high cost and time involvement intrinsic to full-scale testing, numerical simulations are favored over experimental work. Subsequent to a numerical model validated by actual test responses, multiple impact simulations, not practical to full-scale testing, will be investigated to ensure safety during an Orion ground landing.

Accomplishments:

1. Swing test computer simulations were created over the summer for two swing test cases, 0° capsule pitch and -15° capsule pitch. The computer simulations proved the accuracy and weaknesses of numerically modeling capsule land landings. The computer simulations capture the vertical capsule response better than horizontal response, where the horizontal response is more soil dependent. However, the computer simulations do capture the general behavior during a capsule land landing. In addition, computer simulations were conducted varying friction between the boilerplate and soil to investigate capsule stopping distance after soil impact as a function of friction.

2. Numerical modeling was used to investigate proposed vertical drop tests to establish a test protocol and determine required test facility dimensions for accuracy and safety.
3. The soil test mat has been positioned within the NASA Langley Vertical Test Apparatus (VTA). The soil test mat was lifted in 8-in soil layers, compacted and moistened. Soil testing was conducted during the soil lifts to ensure soil uniformity and goal material properties.

Future Work:

Subsequent to the twenty-one swing tests conducted at the NASA Langley Landing and Impact Research Facility (LandIR), the NASA Langley Structural Dynamics Branch will conduct vertical drop tests. Twelve vertical drop tests are proposed to supplement the previous swing test study. The vertical drop tests will be used to calibrate and validate computer simulations of Orion land landings. The tests include varying: impact velocity (12 fps, 24 fps, and 36 fps), boilerplate pitch (0° and 20°), and soil slope (0° and 20°).

A major future research emphasis will be to modify computer code soil parameters with actual in situ soil conditions. To accomplish this objective, a correlation is being developed between hemispherical penetrometer soil testing and numerical response.

Pending Publications:

Heymsfield, E. and Fasanella, E.L., “Using Numerical Modeling to Simulate Space Capsule Ground Landings”, Transportation Research Board, submitted for review for publication and presentation.

Seminars Presented (presented by E. Heymsfield):

Fasanella, E.L. and Heymsfield, E., “Capsule Module Land Landing Using Numerical Modeling”, presented by E. Heymsfield to the NASA Langley Structural Dynamics Branch, June 18, 2008

Fasanella, E.L. and Heymsfield, E., “Vertical Drop Testing Computer Simulations”, presented by E. Heymsfield to the NASA Langley Structural Dynamics Branch, July 16, 2008

Heymsfield, E., “Computer Simulations to Model Space Capsule Ground Landings”, presented by E. Heymsfield to the NIA, August 13, 2008.