Final Report

REDUCED GRAVITY MULTIBODY DYNAMICS TESTING

submitted to

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, AL 35812

under

CONTRACT NO. NAS8-39131
Delivery Order 020

submitted by

Meija Sillanpaa

Department of Aerospace Engineering
College of Engineering
Engineering Experiment Station
Auburn University, AL 36849

June 30, 1993

Introduction

The NASA Marshall Space Flight Center's Center Director's Discretionary Fund (CDDF) "Reduced Gravity Multibody Dynamics Testing" experiment was conducted on board the NASA KC-135 RGA in Houston, Texas. The objective was to analyze the effects of large angle rotations on flexible, multi-segmented structures. The flight experiment was conducted to provide data which will be compared to the data gathered from ground tests of the same configurations. The flight and ground tested data will be used to validate the TREETOPS software, software which models dynamic multibody systems, and other multibody codes.

The flight experiment consisted of seven complete flights on board the KC-135 RGA during two one-week periods. The first period of testing was April 4 to April 9, 1993. The second was June 13 to June 18, 1993.

First Week of Tests

During the first week of tests, the multibody test article was configured with the eight foot aluminum, ladder beam and two thin, flexible, steel beams attached to one end by a joint. Sixty accelerometers were attached to the structure. The accelerometers, three in each position to measure acceleration along each of the x-, y-, and z-axes, were placed in twenty positions.

Four days of flights were executed. The number of reduced gravity maneuvers completed varied each day, with forty, sixty, forty, and sixty maneuvers, respectively.

During pre-flight, the angle between the two flexible beams and the eight foot beam was varied, from 90 to 180 degrees, each day for the four different configurations. The angle between the two flexible beams was kept constant, at forty-five degrees.

During each flight, the test article was released in the near zero-gravity environment, which lasts for approximately twenty-five to thirty seconds. The free-floating multibody truss structure was impacted with a hammer at the end opposite the joint on the eight foot ladder beam. The accelerometers gathered the data on the vibrations of the structure. The data was recorded on tapes for later analysis at Marshall Space Flight Center in Huntsville, Alabama. The test structure's vibrations were recorded from the moment of impact by the hammer until the structure contacted one of the walls, ceiling, floor, or another object. The average free-float time was four to five seconds.

Second Week of Tests

During the second week of tests, the multibody test article was configured using the six and a half foot aluminum, ladder beam attached by a joint to the eight foot aluminum, ladder beam that had the two thin, flexible, steel beams attached by another joint. Seventy-five

accccelerometers were attached to the structure. The accelerometers, three at each position for measurement of acceleration along the x-, y-, and z-axes, were placed in twenty-five positions. Three complete days of flights were executed. The number of reduced gravity maneuvers completed each of the three days was sixty. One full day of flight was lost due to mechanical problems, with only eight reduced gravity maneuvers completed on that day. During pre-flight, the angles between the six and a half foot and the eight foot ladder beams and between the two flexible beams were varied, from fifteen to forty-five degrees, each day for the three different configurations.

During the flight, the test article was released in the near zero-gravity environment. The free-floating multibody truss structure was impacted with a hammer near the joint between the two ladder beams, on the eight foot ladder beam. The accelerometers gathered the data on the vibrations of the structure. The data was recorded on tapes for later analysis at Marshall Space Flight Center. The test structure's vibrations were recorded from the moment of impact by the hammer until the structure contacted one of the walls, ceiling, floor, or another object. The average free-float time was, also, four to five seconds.

Data Quality

Good data was obtained, although some problems were encountered during the second week of flight testing. Data was not obtained from only one configuration. This was due to a mechanical problem on board the aircraft and weather problems. The latter portion of the data collected from the last of the three configurations was, also, less than the quality of the other data, due to the weather. The problems experienced, in this configuration, were short float times due to turbulence from an approaching tropical storm. Despite these occurrences, good data was collected during the second week of flight testing.

Conclusion

The flight tests on board the KC-135 RGA were conducted successfully. Good data was obtained during both weeks. The data from the first week of tests has been partially analyzed, and the results are encouraging. The differences caused by the effects of the gravity on structures that experience large angle rotations that have been observed in the data are generally as expected.