DYNAMIC SCALING FOR EARTH BASED TESTING OF MARS TERMINAL DESCENT DYNAMICS

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The gravitational and atmospheric differences between Earth and Mars compromise flight-testing of Mars descent systems on Earth. The inadequacy of such testing is particularly acute if aerodynamics is used to balance gravitational forces during terminal descent - as is the case for the 2003 Mars Exploration Rover (MER) mission. In this situation, full-scale tests with the Mars flight hardware do not recreate the Mars dynamics and may not represent a validation of the terminal descent systems performance. Performance validation is then relegated to dynamic model simulations. Fortunately, dynamic scaling laws can be utilized to design a scaled flight test that recreates the important interplay between aerodynamics and gravity as a means of validating these simulations. The purpose of this paper is to outline the derivation of the dynamic scaling laws for Earth based testing of this type of Mars terminal descent system as well as present the design and results from the MER Multi-body dynamics test conducted in the winter of 2002.

Dynamic scaling laws for terrestrial aerodynamic systems have been studied and used to design scaled tests for many decades[1]. These tests enable controlled examination of complex dynamic phenomena such as aircraft spin[2]. Since most aerodynamic problems are both flown and tested on Earth, there has been little need to extend these scaling laws to include gravitational differences between the test and flight environments. Space missions that include landing on other planets with atmospheres present the only application. In addition, the 1976 Mars Viking mission relied solely on engine thrust for terminal descent so such a test was unnecessary to validate that system. The terminal descent system for the MER mission, however, does rely on knowledge of the dynamic interaction of the descent parachute with the 2-body pendulum suspended mass to validate the systems performance. Thus, the present work represents the first large-scale field-test for a flight mission utilizing these dynamic scaling laws.

The full paper will derive the dynamic scaling laws for Earth based testing of Mars terminal descent dynamics. It will compare dynamics results from a simulation of the equivalent Mars flight to Earth test and discuss limitations of this type of testing It will briefly describe the design of the MER multi-body dynamics test and summarize data collected during that test. This work has application to design and testing of future planetary landers.

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References:

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