Paper ID: 10684
oral
student

SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

Author: Mr. Sydney Do
Massachusetts Institute of Technology (MIT), United States, sydneydo@mit.edu

Dr. Olivier de Weck
Massachusetts Institute of Technology (MIT), United States, deweck@mit.edu

A PERSONAL AIRBAG SYSTEM FOR THE ORION CREW EXPLORATION VEHICLE

Abstract

In the development of any crewed capsule-shaped spacecraft, the requirement for protecting astronauts from the impact loads incurred during landing, along with the landing mode to be employed, become fundamental design drivers. This was indeed the case with Orion Crew Exploration Vehicle (CEV), where a nominal land-landing mode was originally planned, but a water-landing mode was ultimately adopted due to difficulties in keeping the vehicle to within its mass allocation. In recognizing this, the concept of a personal airbag system was identified as being a potential means for providing a low mass, reconfigurable alternative to the current system intended to protect astronauts from landing impact loads. This paper presents the study undertaken to determine the feasibility of this concept in providing adequate impact attenuation during nominal Orion CEV land-landings at impact velocities of 7.62m/s (25fps). Here, a system development approach has been employed to determine feasibility, whereby two generations of full-scale personal airbag systems were developed, and subjected to a series of drop tests involving land-landings at various impact velocities and angles. Through this effort, the personal airbag concept has been experimentally shown to be capable of maintaining the risk of injury to the occupant during a 7.85m/s, 0 degree impact angle land-landing to within the NASA specified limit of 0.5%. In accomplishing this, concept feasibility has been established. In addition, the obtained test results suggest that by incorporating anti-bottoming airbags to prevent direct contact between the system and the impacting surface, the system performance can be improved by at least a factor of two. Moreover, a series of drop tests at the nominal Orion impact angle of 30 degrees suggest that severe injury-risk levels would be experienced at impact velocities upwards of 5m/s. This is a result of differential stroking between the airbags within the system, causing a shearing effect between the occupant seat structure and spacecraft floor, which in turn removes a significant amount of stroke from the airbags. Combined, these results suggest that with the implementation of anti-bottoming airbags and the enforcement of a flat impact angle, the personal airbag system may prove to be the key to achieving land-landings with the Orion CEV whilst remaining within its mass allocation.