RF Characterization of the Mars Exploration Rover Radar Altimeter Antennas-Airbag Interaction

Ziad A. Hussein, and Scott Shaffer
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
Ziad.A.Hussein@jpl.nasa.gov
Tel: (818) 354-0533

This paper presents the experimental and theoretical results of the Mars Exploration Rover-03 (MER) radar altimeter antennas-airbag interaction. The objective of this work is to determine the impact of the MER airbag on the radiation properties of the radar altimeter antennas, and how transparent the airbag is to the RF signal, in order to ultimately assess any impacts or risks to the radar altimeter system, RAS, performance.

The Mars Exploration Rover airbag, when inflated during descent to the Martian surface, may assume different configurations in the proximity of the radar altimeter antennas. With respect to these configurations, the airbag is in the near-field region of the antennas. Hence, the antenna does not uniformly illuminate the airbag. Consequently, for a given airbag type, the antenna input impedance varies depending on the distance between it and the airbag. In other words, the airbag presents an impedance mismatch to the antenna at its design frequency, and the total power reflected back toward the antenna depends on the level of this mismatch. Similarly, the mutual coupling, or total power coupled between the radar altimeter antennas, depends on the load impedance and may vary accordingly. Because the radar altimeter antennas are close (near-field region) to the airbag when it is inflated, we have considered several configurations to characterize the antennas' performance. These characterizations should allow us to determine the proper link budget for the radar altimeter in terms of signal lock during MER descent to the Martian surface.

It is shown that the mutual coupling between radar altimeter' antennas may be affected when the airbag is on top or in the close proximity to the antennas, 0 to 15.24 cm, and the radar may not function properly for certain orientations and positions of the airbag within this region. It is demonstrated that as the airbag is withdrawn away from the antennas (toward the far-field region of the antennas), the antenna's performance will be decoupled from the airbag. In addition, it is shown that the airbag in the close proximity of the antennas, 0 to 6.35 cm, may degrade the antenna radiation patterns. This degradation appears as a ripple in the amplitude patterns.

Based on the results presented here, it is shown that it is necessary for the MER baseline to delay airbag inflation until after the flight algorithm has computed the final RAS ignition and bridle cut times. This will prevent the radar receiver from locking on the coupled signal from the transmit antenna due to the airbag instead of the reflected signal from Martian surface.