HUMAN SPACEFLIGHT SYMPOSIUM (B3)
Human and Robotic Partnerships in Exploration - Joint session of the Human Spaceflight and Exploration Symposia (6-A5.3)

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CHARACTERIZATION OF THE WHEEL-TERRAIN INTERACTION FOR PLANETARY ROVER WHEELS

Abstract

All robotic rovers for planetary exploration and the vehicles used to carry astronauts on the surface of the Moon used wheels as running gear. The same applies to the majority of projects for future exploration missions, both of the unmanned and manned types. While the wheels used on the large majority of ground vehicles used on Earth are based on pneumatic tires, on airless worlds, particularly in case of planets where there is a high level of ultraviolet and ionizing radiation, are usually non-pneumatic. The great advantages of compliant wheels suggested to use elastic, airless tires. Airless wheels were developed since the beginning of automotive technology, with the aim of avoiding the allegedly unreliable pneumatic tires, but with the improvements of the latter and the increased confidence of the users, they practically disappeared. Airless tires were applied again for planetary exploration vehicles and, in particular, the Lunar Roving Vehicle (LRV) of the Apollo program had wheels of this kind. More recently, Michelin introduced the tweel, an airless elastic wheel, also for Earth application. Dynamic modeling of wheeled vehicles is a common practice in automotive technology, and commercial codes are usually employed. Such dynamic modeling however requires a knowledge of the wheel-terrain interaction that is usually beyond that available for the specific type of wheels designed for planetary rovers, in particular when they operate on regolith like in the actual working conditions. Several analytical wheel-terrain interaction models have been discussed in detail in the literature but, although many tests were performed in the past (starting from the 1970s for the Apollo LRV missions) there is a substantial lack of experimental data. Test campaigns aimed at characterizing the behavior of the specific non pneumatic, elastic but sometimes rigid, wheels designed for planetary rovers are required. The tests must be performed on specific soils that simulate the terrain which can be found in the actual applications, the so-called planetary simulants. The aim of the present paper is to describe a test rig that can be used to characterize the wheel-ground interaction under different operating conditions and its use for the wheel designed for a small lunar robotic rover. The sideslip and camber angles of the wheel can be adjusted in a wide range to obtain a complete wheel characterization. Different soils spanning from artificial hard surfaces to simulants for Mars and Moon regolith can be used.