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INNOVATIVE MARS EDL GNC TECHNOLOGIES FOR FUTURE CHINA MARS EXPLORATION

Abstract

Mars landing exploration activities have been and will continue to gather scientific data and deepen the current understanding about the life origin and the solar system formation process. All Mars landers to date continue to rely on the entry, descent and landing (EDL) technologies developed for the Viking missions in the mid-seventies of the last century. Viking-like landers adopt inertial measurement unit (IMU) based navigation mode and unguided ballistic trajectory entry without life control, which lead to larger landing error ellipse and lower altitude landing site restriction. With the advances of technologies, estimated Mars landing accuracy to date has gradually improved from 150 km of Mars Pathfinder to 35 km for the Mars Exploration Rovers to 10 km for 2011 Mars Science Laboratory (MSL). It is believed that MSL is challenging the capabilities of Viking-heritage EDL technologies, defining an upper bound on the performance of the first generation EDL systems and GNC mode. Future Mars missions, such as Mars sample return, manned Mars landing and Mars base, need to achieve the pin-point Mars landing (safe landing within tens of meters to 100 m of a preselected target site). Since the current EDL system and GNC methods can not satisfy the requirements for future pinpoint Mars landing missions, the next generation of EDL system and GNC methodologies are required in order to deliver the largest and most capable lander/rover to date to the surface of Mars. In this paper, we will report the latest progress on Mars EDL navigation, guidance and control in China. In order to overcome the defect of traditional IMU based navigation, we develop the new estimation methods and integrated navigation for Mars entry, descent and landing. External navigation observation information from radio, radar and camera are included in the integrated navigation scheme to improve the navigation accuracy. At the same time, active entry guidance methods are proposed to improve the guidance performance with the larger parameter uncertainties using robust and adaptive control theory.