

Integrated Navigation and Guidance for Precision Landing at Mars

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Extended Abstract

The primary requirement of the next generation entry descent and landing (EDL) systems is to reduce the size of the landing zone for a Martian lander from the currently acceptable uncertainty of hundreds of kilometers to under ten kilometers. The NASA effort, led by the Jet Propulsion Laboratory, relies on several techniques never before utilized at Mars, namely, a guided entry and an altitude-velocity dependent parachute deploy logic. The proposed Mars '07 Smart Lander will be the first demonstration of a real-time onboard precision navigation and guidance capability at Mars. In addition to reducing the landing site footprint, the Mars '07 Smart Lander will demonstrate terminal phase hazard avoidance. The concept is to use onboard sensors to generate a terrain map of the proposed landing site and surrounding area. The system will process the terrain data and determine a safe zone within the scan area. If the projected landing site is deemed hazardous, a new landing site is selected and the spacecraft automatically retargets the new site.

An advanced technology development program has been initiated to develop the new technologies required to achieve the required landing accuracies for the next generation Martian landers. The guided entry and hazard avoidance systems require accurate knowledge of the position, velocity, and attitude (i.e., the state) of the spacecraft in real-time. Accurate state information is needed by the guidance system throughout all entry phases: pre-parachute deploy hypersonic entry, parachute deployment phase, and terminal guidance utilizing the main landing engines. The state information is also required for accurate determination of the landing site location on the Martian surface.

The determination of the current state of a spacecraft maneuvering in the Martian atmosphere is the subject of this paper. The task of the precision navigation system is to supply the current state of the spacecraft, as well as a measure of the uncertainty associated with the current state estimate, to all other spacecraft systems that need the information. The proposed technique employs a recursive filter (that is, an extended Kalman filter) processing data provided by a strapdown IMU and aided by external sensor data. The proposed external sensors are a scanning lidar and a phased-array radar, both of which supply altitude and velocity data, along with a terrain sensing capability.

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This focus of this paper is the interaction of the aided-navigation system with the rest of the flight system. Of particular interest, is the integrated guidance and navigation system performance. Results from simulated EDL scenarios representative of the Mars '07 landing will be presented. The entry scenario considered extends from cruise stage separation to touchdown.