SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 2 (2B)

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PREPARING FOR FUTURE PLANETARY EXPLORATION: AN AUTONOMOUS HAZARD AVOIDANCE AND PRECISION LANDING SYSTEM

Abstract

There is a clear growing interest among international space agencies in order to realise manned and unmanned Moon and Mars exploration missions. Along the critical path to achieve this goal, advanced guidance, navigation and control technologies are required in order to guarantee spacecraft safety and accuracy when orbiting and landing on the surface of celestial bodies. The ability to perform (1) autonomous Hazard Detection and Avoidance (HDA) and (2) high-precision landing using Terrain-Relative-Navigation (TRN), both relative (for velocity determination) and absolute (for position determination), form part of the most challenging requirements for these missions.

Various studies have concluded that these requirements are best satisfied by a combination of Lidar-based and camera-based technologies, complemented with image data processing software as well as autonomous Guidance, Navigation and Control (GNC) software. Such systems have been identified as critical components for the upcoming manned and unmanned exploration programs, but have currently no flight heritage and are at a low technology readiness level. One critical element is the validation of these technologies in a realistic environment where the dynamics, the measurements and the processing capabilities of a real mission are reproduced on Earth to validate these technologies before flight.

The paper will present the concept of a Feature-based Planetary Navigation System (FPNS), combining a Lidar, a camera and GNC software, able to perform both HDA and TRN in support to future missions. The paper will also address the various validation steps for such systems: numerical simulations, laboratory emulation and helicopter-based flight demonstration and will present validation results examples for each step.

The paper extends the scope of a previous paper presented at IAC in 2010, which described the three levels of validation of the FPNS. It provided preliminary results on the first two levels using Lidar-based techniques only. The current paper extends these validation results to camera-based navigation techniques, by simulation and in the laboratory, and will in addition present the first ever real-time flight demonstration of a Lidar-based HDA system on-board a piloted helicopter.