Abstract

The LUNar Surface Environment (LUSE) testbed was developed with Embry-Riddle’s Space Technology Laboratory to create an apparatus in which to simulate impacts on the surface of the Moon. LUSE was designed in such a way where test articles could be dropped into the testbed, but other experiments can be performed as well. The LUSE testbed consists of a layer of sand and rock topped with a layer of LMS-1 Lunar Mare Regolith Simulant supplied by the Exolith Lab at the University of Central Florida. The testbed is encased in plexiglass to allow for sensors to observe impacts in a safe environment. Student research projects now can test various theories and projects. Recently, the EagleCam team used the LUSE testbed to simulate their CubeSat’s impact on the surface of the Moon. An EagleCam model was dropped from a scissor lift at the MicaPlex to validate the dynamics model by capturing the impact through an inertial measurement unit inside the model and a high-speed camera.

Methodology

The LUSE test bed consists of a Capture Bay filled with simulant, and Sensor Bench to record data. The apparatus can be seen in Figure 2 below.

The LUSE Test Bed currently consists of:
• 0.71 x 0.96 x 0.79 m Capture Bay
• 0.15 m bottom layer of sand and rock
• 0.05 m top layer of LMS-1 Lunar Mare Regolith Simulant supplied by Exolith Lab at UCF
• Two clear plexiglass panels for sensors, a checkboard for post processing analysis, and blacked out panel to control brightness
• Removable cover with gloves to safely handle regolith coated objects
• PCO dixmax HS4 camera capable of 7000 frames per second on loan from The Wind Tunnel Facility
• Intel Realsense LiDAR Camera L515 which generates 23 million depth points per second
• Velodyne Puck LITE LiDAR with a full 360° fov
• Raspberry Pi High-Quality 180° fov Camera
• Dell Latitude e7450 laptop
• Four Go Pro Hero Black 3’s for extra viewing angles

EagleCam Testing

The EagleCam team has shown the potential of LUSE in their recent paper on validation of LS-Dyna simulation results with experimental data. The shell of an EagleCam Prototype was dropped from a height of 7 ft with an inertial measurement unit attached. The IMU measured an impact acceleration of 8.85/6.01 g shown in the figure below. The large discrepancies were caused by experimental error including inconsistent drop height and velocity, but it was concluded that the true mean impact acceleration was within the simulation impact acceleration range of 5.49 ± 1.74 g.

Furthermore, a separate test was conducted to test flight hardware components ability to withstand impact. For this experiment, an EagleCam prototype was dropped from a height of 25 feet. Upon impact, a transistor malfunctioned cutting all the electronics off from power. This resulted in a crucial design change that will prevent future failure in the power conditioning board. Although data could not be gathered from the IMU, the impact velocity could still be determined through Tracker, an open source software, using the known dimensions of the checkboard and prototype. The impact velocity data was used to validate MATLAB dynamic models, and served as an input into LS-Dyna simulations.

Future Research

LUSE has created the opportunity for various student groups to gather real world data for their projects. The EagleCam team, which is developing a CubSat to film the Nova-C Lander’s descent to the lunar surface, has been using LUSE to both validate simulation model and their internal components ability to withstand impacts. The senior design project LOKI will be conducting a study of how LiDAR can be used to study plumes of lunar regolith as part of their research sponsored the Florida Space Grant Consortium. Lastly, a team of Space Flight Operations is preparing a proposal to test their project in LUSE.

References