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DESIGN AND DEVELOPMENT OF A GROUND BASED ROBOTIC TUNNELING WORM FOR OPERATION IN HARSH ENVIRONMENTS

Abstract

The United States (US) National Aeronautics and Space Administration (NASA) Apollo program missions to the moon, which concluded almost 40 years ago, allowed for the retrieval of lunar soil otherwise known as lunar regolith. However, the diversity of the samples acquired was limited due to the logistical inability of the astronauts to penetrate the moon's surface to a depth greater then 3 meters. In order to achieve a broader knowledge of lunar regolith and its changing nature at various depths, future lunar missions will require the implementation of tools that possess the ability to burrow at various depths and collect samples for subsequent analysis. Furthermore, the elimination of human interaction during the long and strenuous coring process would enable astronauts to concentrate on higher level tasks. To penetrate the 3 meter barrier, a collaborative design effort encompassing teams from the University of Alabama in Huntsville (UAH), Louisiana Institute of Technology (LA Tech), the University of California in Riverside (UCR), Johns Hopkins University (JHU), NASA's Marshall Space Flight Center (MSFC) and the National Space Science and Technology Center (NSSTC) has resulted in the design, analysis, modeling, fabrication and testing a lunar regolith burrowing device – referred to as the Lunar Wormbot (LW). The current article is a ground based development unit designed to replicate the peristaltic motion of an earthworm. The UAH Mechanical and Aerospace Engineering (MAE) design team was comprised of undergraduate students charged with the task of designing and fabricating the robotic body segments of the LW. The UAH team worked in parallel with other undergraduate design teams at LA Tech and UCR. NASA engineers and scientists from the NSSTC, JHU, and MSFC acted as technical advisors for the student teams. The UAH student design team employed the NASA Systems Engineering (SE) handbook as a guide throughout the design and implementation phases. The UAH team has performed extensive technical analyses including the evaluation of structural load conditions, thermal stresses, material stresses and deflections, and operational reliability. In order to verify the developed design, an operational ground based unit was fabricated by the UAH team and tested in a lunar regolith test bed at NASA's Kennedy Space Center (KSC). The presented paper provides an overview of the LW design with an emphasis upon the UAH efforts in association with the design, analysis, modeling, fabrication and testing of the LW body.