Thomas Leps Internship Abstract
University Space Research Association

Date: 07/28/2016   **Document Number: EG-DIV-16-14**

Title: **Thomas Leps Internship Abstract**

Synopsis:
This abstract discusses the work, accomplishments and professional development of Thomas Leps during his summer internship at JSC.

Prepared by: **Submitted to:**

_____   _____
Thomas Leps   **Date**   **Melissa Corning**   **Date**
Planetary Surface Physics Lab   JSC Intern Program Coordinator
Clark School of Engineering   AD4 University Space Research Asociation
University of Maryland College Park   NASA-Johnson Space Center

1 Abstract

An optical navigation system is being flown as the backup system to the primary Deep Space Network telemetry for navigation and guidance purposes on Orion. This is required to ensure Orion can recover from a loss of communication, which would simultaneously cause a loss of DSN telemetry. Images taken of the Moon and Earth are used to give range and position information to the navigation computer for trajectory calculations and maneuver execution. To get telemetry data from these images, the size and location of the moon need to be calculated with high accuracy and precision. The reentry envelope for the Orion EM-1 mission requires the centroid and radius of the moon images to be determined within 1/3 of a pixel 3σ. In order to ensure this accuracy and precision can be attained, I was tasked with building precise dot grid images for camera calibration as well as building a hardware in the loop test stand for flight software and hardware proofing.

To calibrate the Op-Nav camera a dot grid is imaged with the camera, the error between the image dot location and the actual dot location can be used to build a distortion map of the camera and lens system so that images can be fixed to display truth locations. To build the dot grid images I used the Electro Optics Lab optical bench Bright Object Simulator System, and gimbal. The gimbal was slewed to a series of elevations and azimuths. An image of the collimated single point light source was then taken at each position. After a series of 99 images were taken at different locations the single light spots were extracted from each image and added to a composite image containing all 99 points. During the development of these grids it was noticed that an intermittent error in the artificial "star" locations occurred. Prior to the summer this error was attributed to the gimbal having glitches in it's pointing direction and was going to be replaced, however after further examining the issue I determined it to be a software issue. I have since narrowed the likely source of the error down to a Software Development Kit released by the camera supplier PixeLink. I have since developed a workaround in order to build star grids for calibration until the software bug can be isolated and fixed.

I was also tasked with building a Hardware in the Loop test stand in order to test the full Op-Nav system. A 4k screen displays simulated Lunar and Terrestrial images from a possible Orion trajectory. These images are then projected through a collimator and then captured with an Op-Nav camera controlled by an Intel NUC computer running flight software. The flight software then analyzes the images to determine attitude and position, this data is then reconstructed into a trajectory and matched to the simulated trajectory in order to determine the accuracy of the attitude and position estimates. In order for the system to work it needs to be precisely and accurately aligned. I developed an alignment procedure that allows the screen, collimator and camera to be squared, centered and collinear with each other within a micron spatially and 5 arcseconds in rotation. I also designed a rigid mount for the screen that was machined on site in Building 10 by another intern.

While I was working in the EOL we received a $500k Orion startracker for alignment procedure testing. Due to my prior experience in electronics development, as an ancillary duty, I was tasked with building the cables required to operate and power the startracker. If any errors are made

building these cables the startracker would be destroyed, I was honored that the director of the lab entrusted such a critical component with me.

This internship has cemented my view on public space exploration. I always preferred public sector to privatization because, as a scientist, the most interesting aspects of space for me are not necessarily the most profitable. I was concerned that the public sector was faltering however, and that in order to improve human space exploration I would be forced into private sector. I now know that, at least at JSC, human spaceflight is still progressing, and exciting work is still being done. I am now actively seeking employment at JSC after I complete my Ph.D and have met with my branch chiefs and mentor to discuss transitioning to a grad Co-op position.
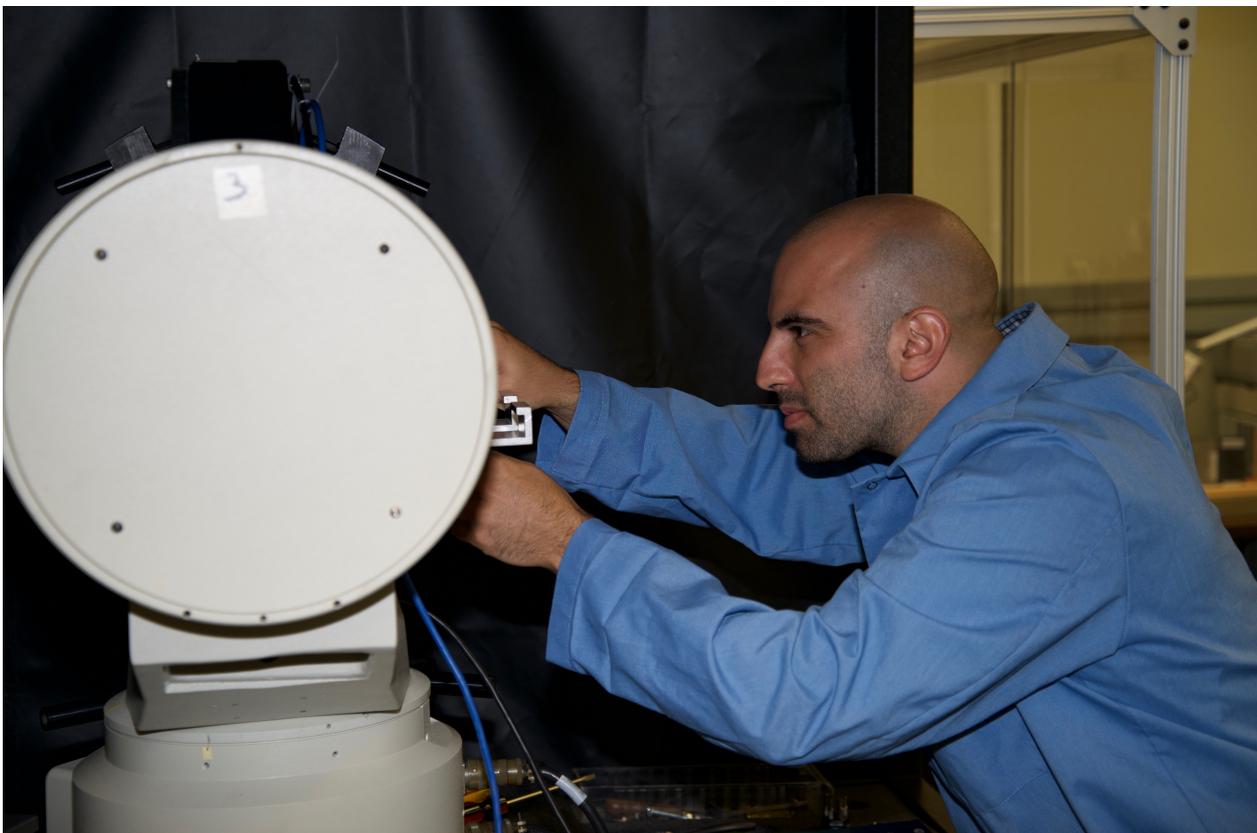
Figure 1: Aligning the Op-Nav camera on the EOL gimbal