Lunar Lander Strut Installation and Alignment

Emily Mun, Evan Phung, Hanyang Xu, Tim Smith, William Hong
Faculty Advisor: Junlan Wang | Industry Sponsor: Blue Origin
Department of Mechanical Engineering, University of Washington

BLUE ORIGIN

INTRODUCTION/MOTIVATION

- The Blue Origin MK2 Lunar Lander is made up of distinct modules mechanically connected with struts that need to be adjusted and set to correct lengths
- Aim to validate a process in which strut length can be correctly measured and installed to the MK2 Lunar Lander mockup
- A successful, and repeatable process is needed to improve efficiency in assembly process

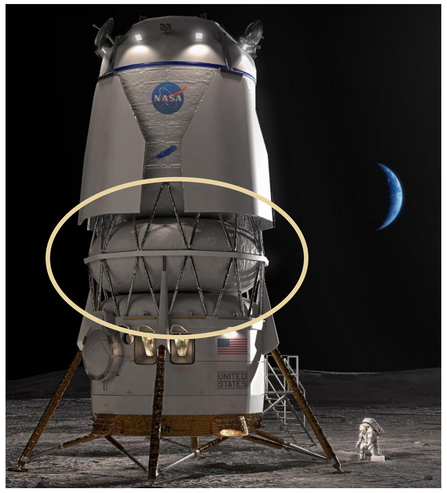

Fig.1. Rendering of the MK2 Lunar Lander with the struts outlined . [1]

PROBLEM STATEMENT

Blue origin needs a repeatable and efficient and process to join the spacecraft modules with adjustable structural struts.

REQUIREMENTS

- Prototype tool that is highly accurate
- Verify tool's functionality and accuracy:
  - Use the Leica (highly accurate laser tracker) to measure and calculate baseline lengths of struts
  - Adjust struts to baseline lengths using the tool
  - Verify that the holes on the sturt ends and clevis mounts align properly without the use of excess force

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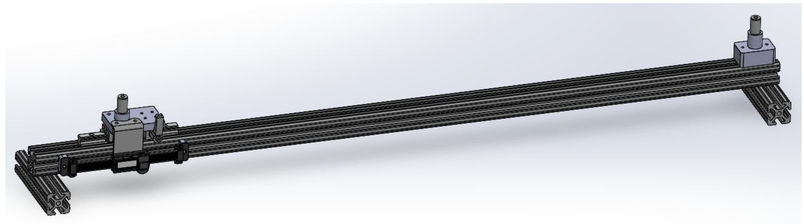
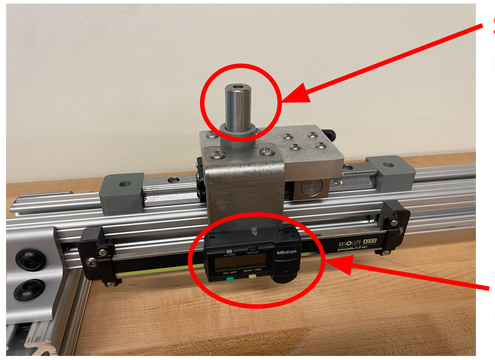
[1] "Blue Moon," Blue Origin, 2019. https://www.blueorigin.com/blue-moon
[2] Hexagon Manufacturing Intelligence, "Introducing the new Leica Absolute Tracker AT500," YouTube, Jun. 08, 2022. https://www.youtube.com/watch?v=ctcIfjummuQ (accessed May 21, 2024).

DESIGN & TEST PROCESS

TOOL DESIGN/PROTOTYPE





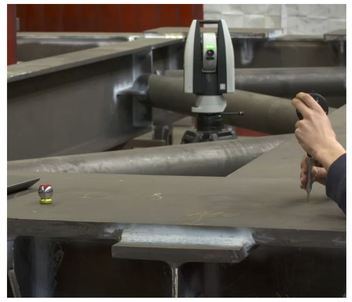
SMR (Spherically Mounted Retroreflector) Placement
-SMR: tool used for Leica to track measurement
-Calibrated using Leica

Linear scale (digital read-out, DRO) +/- 0.0005 accuracy

- T-slotted frames used for the bulk of the tool
- One fixed end (top image: right side of tool) and one free-end (top/bottom image: left side of tool) for placement/adjustment of mock-up strut
- Slider on the free end attached to electronic measuring tool to measure length of strut
- Hand brake attached on the free end to stop movement after correct length of strut is met

TEST PROCESS

- Leica was used to record each data point in 3D space
- Data points processed in SolidWorks for 3D viewing
- Required strut length measured in SolidWorks
- Tool used to set each strut to its required length
- Installed struts clockwise onto the mockup



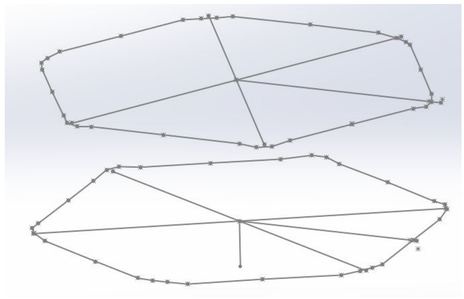
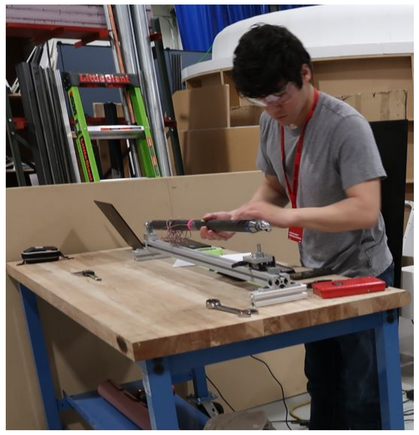


Fig.2. Leica Absolute Tracker AT500. [2]

RESULTS/VALIDATION

- Expectations: the tool is able to set struts to specific lengths and no extra tools are needed (i.e. hammer) to install struts
- No issue of readjusting the strut lengths during installation process
- Leveraging forces were not required to install struts (pounding struts into pins of mockup was not needed)



CONCLUSION & FUTURE WORK

- Successfully created a tool to accurately measure the as-built strut lengths.
- Successfully made a mockup spacecraft mate system and performed the process
- Next step: ensure the process is repeatable and accurate.
  - Blue Origin will repeat the process multiple times to make sure data is accurate
- Include a calibration for each strut before installation
- Add more features to the tool such as a fine adjustment knob to increase accuracy

Acknowledgements

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