Photovoltaic Investigation on the Lunar Surface (PILS)

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Background

- Solar cells have been used on the lunar surface in the past (last NASA use was during Apollo) but the technology has matured significantly
- There is still a lot unknown about the energized environment of the lunar surface and how it would impact high voltage solar arrays
- PILS team responded to a call to provide payloads to the Commercial Lunar Payload Services (CLPS) program, proposing a test-bed to measure electrical performance of state of the art and next generation solar cells, and to measure the charge build up on a small solar cell array
- Selected by Astrobotic (scheduled to be the first commercial lunar lander) with a target landing in Fall 2021 at Lacus Mortis at 45N

Technical Goals/Objectives

- Enhance existing models for future power generation systems, to shape design rules for large solar arrays on the lunar surface
- Determine charge buildup on solar arrays and arcing hazards in the lunar environment
- Increase TRL of cells and arc detection capability

PILS: Requirements and Design Considerations

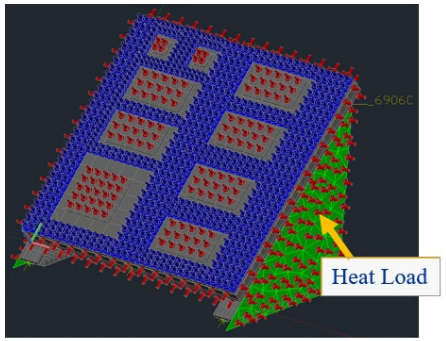
Requirements

- Proposed and accepted payload dimensions, not to exceed: 30 x 30 x 4cm (without mounting brackets)
  - Designed to be mounted flat (without brackets) and scaled in size if testing less cell technologies (adaptable for multiple lander platforms and footprints)
  - Capped mass at 4.5 kg
- Power limited to 2W for solar cell and plasma charging experiment. Additional power for on board heaters was negotiated with Astrobotic during payload design.
- Team designed PILS platform to accommodate interfaces with the AB lander in terms of power, communication, mounting, environmental concerns
- Solar cells include state-of-the-art (qualified and regularly used), next-gen (in-qualification and have had little in-space use), and thinned silicon (a low cost terrestrial technology)

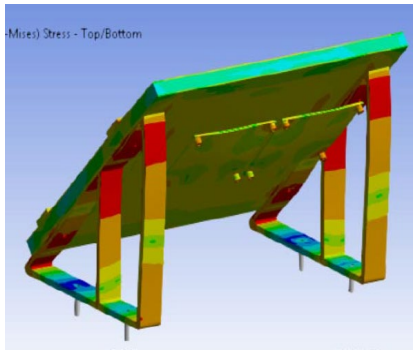
Design Considerations

- Initial concept used solar cell high altitude flight calibration holders but they added significant mass. Found a solution to use a single circuit board type top surface to mount the solar cells
- During early design the launch loads were not well known which presented a challenge to design the platform to be lightweight but still robust. Multiple iterations were considered and modeled to get to the final design.
- The thermal environment turned out to be our largest environmental driver. Challenge to keep the electronics warm during transit to the moon and to keep them cool while on the surface during the lunar day. Found solutions with multilayer insulation and thermal tape.
- Built scaled mock-ups of the platform to better understand interfaces and clearances

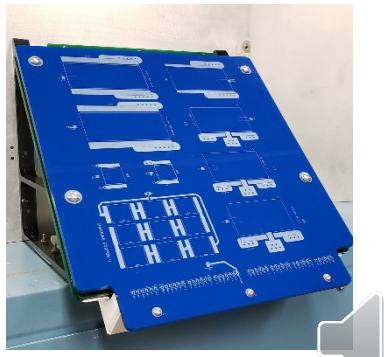
PILS Mock Up Based on Initial Concept



PILS Thermal Analysis Model



PILS Structural Analysis Model



PILS Platform Mock Up

PILS: Flight Hardware Status

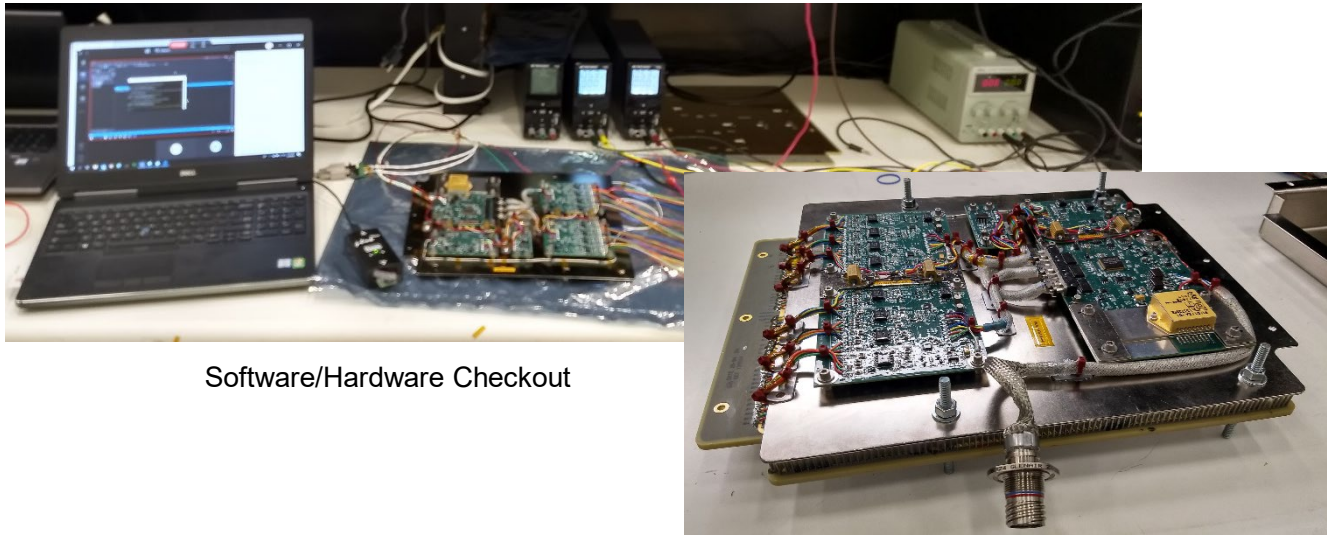
- Platform software and electronics designed and built at GRC
- Platform assembly completed
- Platform was just recently wrapped with MLI

- Contains the following solar cells
  - SolAero (Z4J, IMM-alpha)
  - Spectrolab (XTJ, XTE-SF, UTJ – for charging coupon)
  - Arizona State University (Silicon)

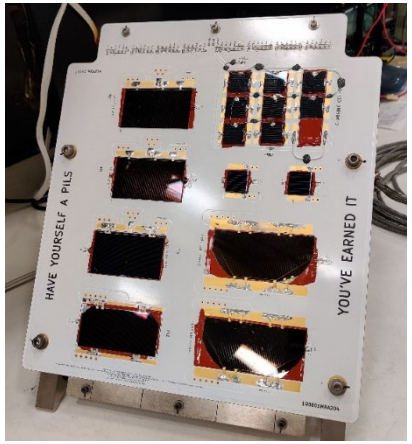
- Completed Environmental Testing
  - Thermal Vacuum Performance (hot & cold)
  - Electromagnetic Interference Compliance
  - Vibration Structural Testing

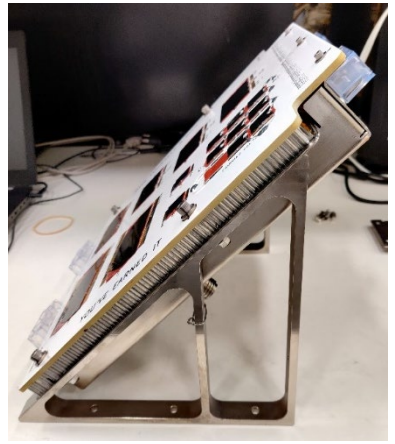
- Deliver to Astrobotic for Integration (June 2021) and Flight (Q4 2021)

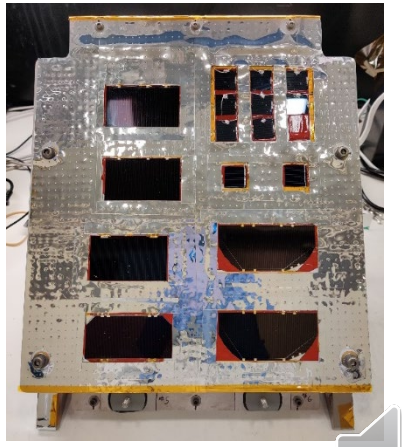
- Results shared at Space Power Workshop 2022



Software/Hardware Checkout







Assembled PILS Flight Unit

Assembled PILS Flight Unit with Thermal Tape Applied to Top Surface