National Aeronautics and Space Administration

TBD

Mid-wave Infrared Illuminator for Lunar Ice Perception Algorithm (LIPA)

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EXECUTIVE SUMMARY

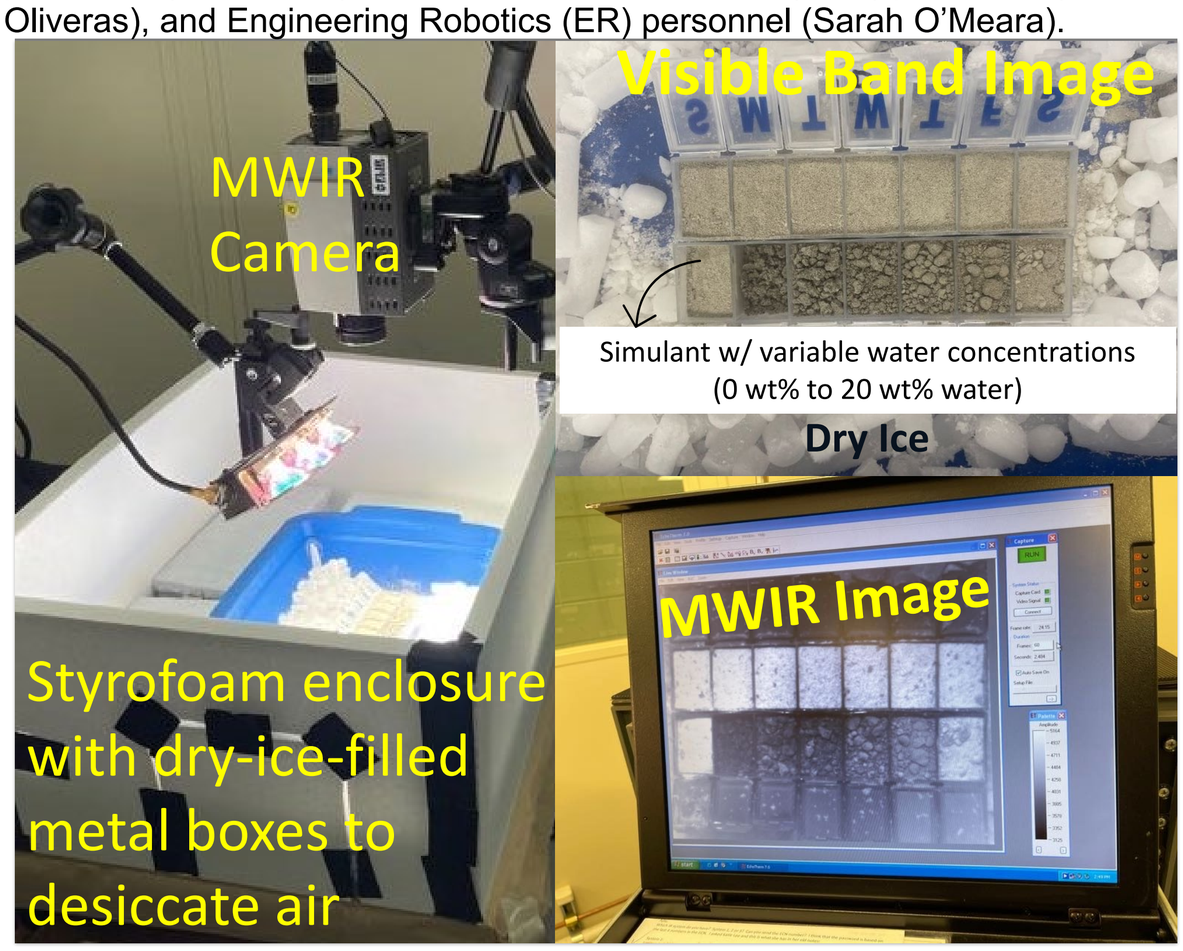
The team from the Image Science and Analysis Group, Simulant Development Laboratory, and Non-destructive Evaluation Laboratory performed product searches and hardware testing to identify the most promising current technology to support MWIR illumination for LIPA testing and any eventual hypothetical lunar fielding. LIPA uses response differences between two bands to detect water ice. The team identified incandescent, semi-conductor, and laser technologies capable of generating MWIR illumination in at least a portion of the spectrum required by LIPA. However, only incandescent sources appeared to jointly meet constraints for size, wavelength, power output, and simplicity of control. Finally, the team obtained actual product information for an incandescent illuminator, the Helioworks EP-4317, associated with an IR sensor planned to be fielded on a lunar rover, the Resource Prospector (RP) that was the predecessor to the VIPER concept, which shares the relevant NIRVSS sensor. It was assumed that those who originally decided upon the use of that illuminator for the RP had considered other options and found the incandescent illuminator to be optimal for their needs, which closely match the presumed usage of LIPA were *it* to be fielded on the Moon. The team concluded that there was no further need to pursue non-incandescent technology for LIPA, ordered units of the EP-4317 and used various incandescent illuminators already on hand, while waiting for the EP-4317 hardware, to support LIPA testing.

INNOVATION

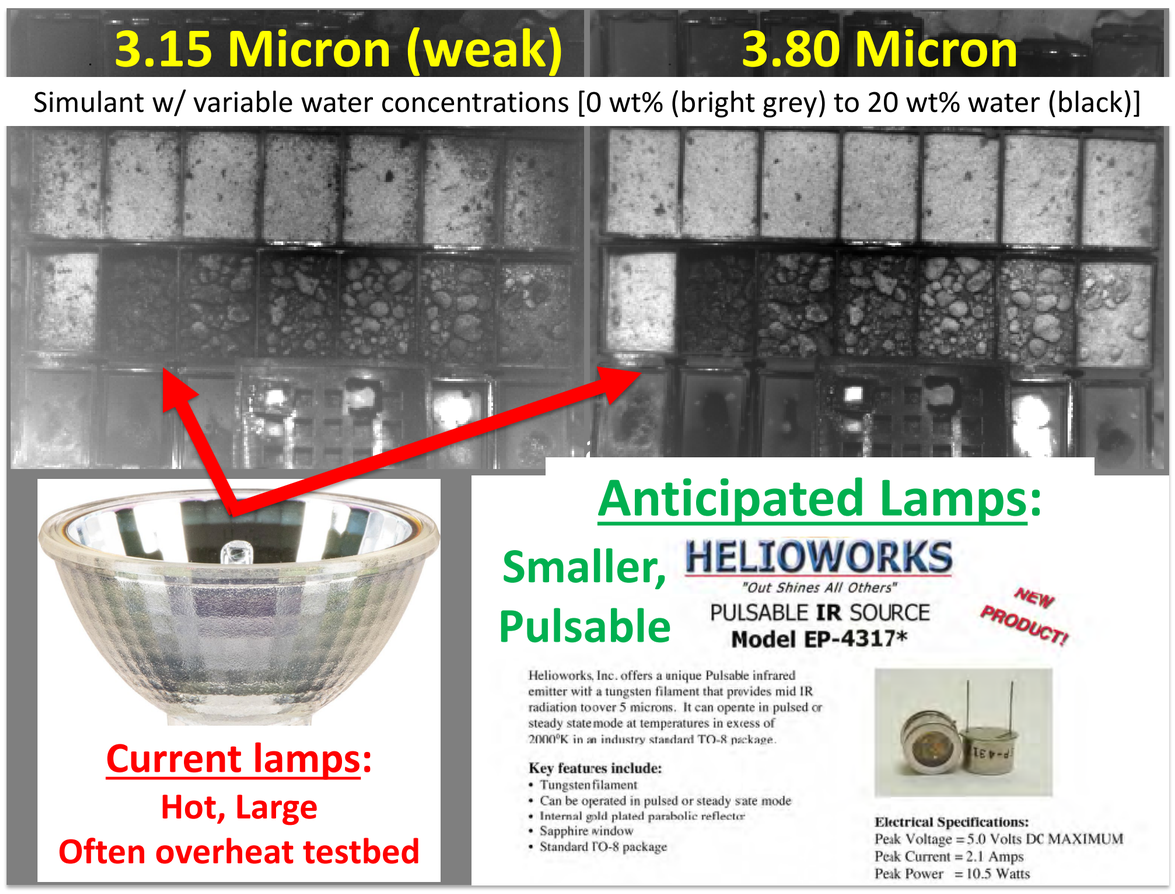
Concluded that incandescent MWIR sources are sufficient to provide needed illumination to support LIPA, at least to the extent that the ice to be detected is water ice. The current LIPA setup involves high-intensity halogen movie projector bulbs, whose operation simply involves turning a switch on or off. Current and anticipated sources support the two MWIR narrowbands needed for LIPA. Anticipated source more controllable. LIPA innovation supports future robotic and human missions to the moon which aim to identify water-ice zones. The positive identification of Lunar volatiles, such as water-ice, in the regolith is vital for a sustained human presence on the moon (e.g., water can be served as a source for oxygen and hydrogen which in turn, can be a source of rocket fuel).

COLLABORATION

Image Science and Analysis Group (ISAG) personnel (John Rollins, Sam Pomajevich, Eric Huang) collaborated with Simulant Development Lab (SDL) personnel (Ane Slabic), Non-destructive Evaluation (NDE) personnel (Ovidio Oliveras), and Engineering Robotics (ER) personnel (Sarah O'Meara).



Projector-Bulb Incandescent Illumination of Water-ice/Lunar-dust-simulant Testbed



Incandescents are easy to control, but more control is needed than what we have now as we're always trading off weak signals (lamps too far away) with overheating the test bed.

OUTCOMES & INFUSION

State your projects outcomes (technical and infusion accomplishments), notable deliverables, TRL advancement and process or program infusions.

1. LIPA results, such as those presented here, can be achieved with the use of incandescent lamps. However, the more control we have over illumination power and duration, the more likely we are to get good MWIR image exposures without influencing the testbed temperatures (i.e., heating of simulant surface and subsequent melting of ice).
2. We have evidence that others have chosen incandescent lamps for the same job in the near past and have identified the specific incandescent lamps they planned to use. Unknown if those plans carried over from the Resource Prospector to the VIPER. From *"Volatile monitoring of soil cuttings during drilling in cryogenic, water-doped lunar simulant" [Roush et. al., 2018]: "The lamp is a commercially available infrared source (Helioworks Inc., model EP-4317) operated in continuous mode."*
3. We have achieved some control over the testbed environment by making water-vapor cold traps with metal boxes filled with dry ice. It's possible that water vapor is still partially spoiling our experiments.

FUTURE WORK

Describe planned future work, pursuits and next steps

1. Receive EP-4317 lamps and test with them. Buy more if needed.
2. Optimize test procedure
    1. Determine best number of illuminators and pulse duration.
    2. Develop flat field processing for camera to get consistent exposure response across field of view.
    3. Improve use of reflectance standards.
    4. Improve efficiency in switching MWIR narrowband filters and refocusing.
    5. Improved air desiccation process or perform testing in vacuum chambers.
    6. Understand how water ice truly presents in regolith given that it generally impacts at several miles per second and presumably gasifies before condensing on regolith grains. Perform hypervelocity impact testing in vacuum? Just wait and see what VIPER sends back?

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