National Aeronautics and Space Administration
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Lander Lighting to Reduce Approach Errors

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Technology Taxonomy Area (TX): TX02.2.3 Vision and Augmented Reality Avionics, TX06.6.1 Human Factors Engineering, TX09.4.1 Vehicle Systems Architecture Design & Analysis, TX17.2.4 GN&C Relative Navigation Aids

TRL: Start 2 / Current 4

FY22 ICA PROJECT OVERVIEW

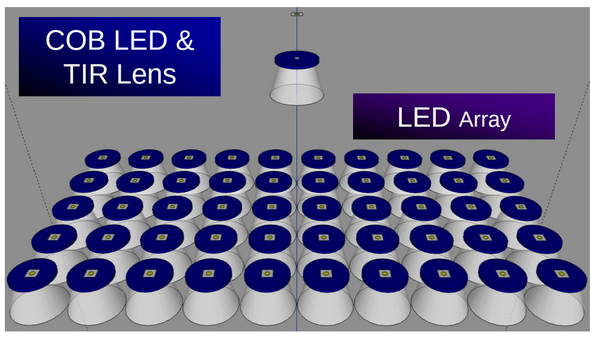
The south pole lighting environment will have harsh low inclination sunlight, making overhead judgement of surface features difficult. Autonomous solutions are great, however, the need for visual monitoring and independent go/no-go decisions remain. Our project proposes that lunar landing systems will be better served by including a powerful landing light system that improves visibility of surfaces from overhead by illuminating the ground at critical distances for the crew to make last minute decisions regarding an approach. The project utilized a computer-based optical modeling software to predict requirements for a potential landing light system. The analysis based the lamp prediction from commercially available LED chip sets and lamp optics. The goal is to illustrate a method to raise the surface contrast of a landing site within an acceptable contrast threshold for most camera systems and human observers to recognize hazards that would not be noticed with low inclination sunlight alone. In doing this analysis we hope to provide guidance on the optical and power system needs to provision a vehicle to provide this piloting safety feature.

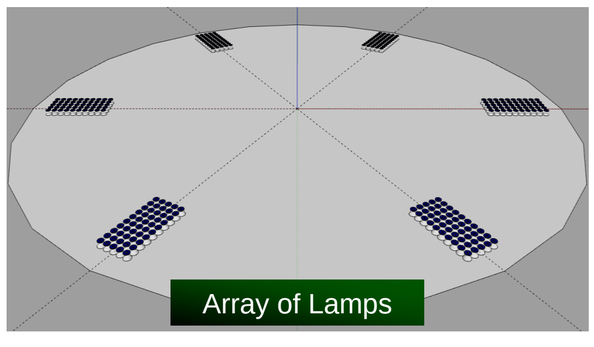
INNOVATION

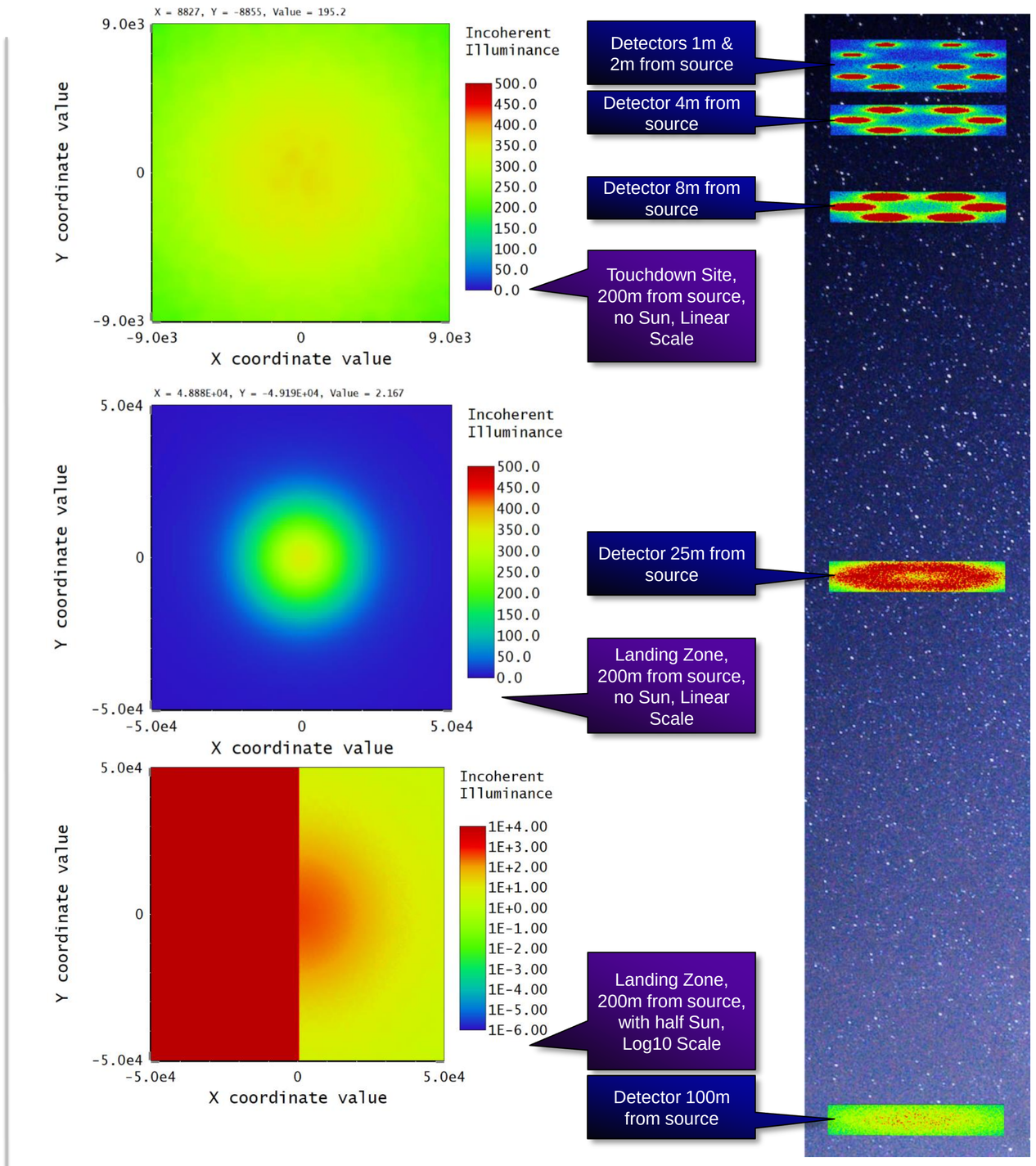
The human eye adapts to 2-3 orders of magnitude brightness. The goal of our lighting system design was to determine the requirements to elevate the surface illuminance from 200 meters away from the ground, such that we restricted the order of magnitude difference between a horizontal surface illuminated by the Sun at an inclination angle of 2-7 degrees and shadow illuminated by the lander to 2 orders of magnitude. Artemis landing sites will have an estimated horizontal surface illuminance of 13,000 lux. We developed a lighting system concept that is predicted to provide an average of 350 lux across an 18-meter illumination Touchdown Site.

OUTCOME

The design was modeled in Zemax Optics Studio, a which is a forward raytracing software often used for agile lighting design projects. The proposed system utilized a CREE Chip On Board (COB) LED Model 1520. COB LEDs are designed to run at higher voltage and wattage levels. Our LED was set to 17 watts and paired with a 67 mm Carlco Optics Ultra Narrow Total Internal Reflection (TIR) silicone lens. The Full Width Half Maximum (FWHM) of this lens is 6.9 degrees. The LEDs were then placed into multiple array sets and then arranged in a circumferential pattern around the base of a hypothetical lander bottom. A total of 300 LEDs were used for the entire system. At 17 watts an LED, the system power requirement is estimated to be 5100 watts. The CREE LED evaluated has a typical forward voltage of 33V, allowing for more robust driver design especially for typical spacecraft that have operating voltages of 120VDC.







INFUSION SPACE / EARTH

The Space to Earth impact from this research correlates to search lamp design and design of lighting environment informed land-based crew virtual environment training facility environments.

PARTNERSHIPS / COLLABORATIONS

The project team represents a collaboration with the JSC Lighting Lab and the Human Factors & Ergonomics Lab. Much of the driving need for this technology to be present on the landing system for South Pole Landing site activity, is the harsh Orbital Lighting Environment and the need for the crew to be provided with a system that improves the usability of visual monitoring systems for time critical vehicle piloting decisions.

FUTURE WORK

In addition to landing scenarios, this evaluation is applicable to lunar rover and lunar worksite lighting applications. The next step is to coordinate with appropriate stakeholders, regarding the evaluation and power requirements, to start a discussion regarding landing concept of operations, risk management, and vehicle power system requirement needs to maintain crew visibility during critical landing operations.

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