

COMPUTATIONAL MODELING TO LIMIT THE IMPACT DISPLAYS AND INDICATOR LIGHTS HAVE ON HABITABLE VOLUME OPERATIONAL LIGHTING CONSTRAINTS

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EVALUATION OF REASONABLE SENARIOS REGARDING IMPACTS TO SPACECRAFT LIGHTING

In late 2016, the lighting environment for the International Space Station will begin to be updated with a new lighting system. The Solid State Lighting Assembly (SSLA), a Light Emitting Diode (LED) technology, which is multi-spectral and intended as a lighting countermeasure to improve crewmember sleep, will replace the General Luminaire Assembly (GLA), a fluorescent based lighting technology. The transition is necessary and intentional for the maintenance of task level lighting and the implementation of visible light spectrums designed to improve crew circadian regulation. During the development of the SSLA, it was discovered that an LED indicator mounted in the fixture caused the SSLA to fail certain visible light spectrum tests. The problem was resolved via operational constraints on the LED indicator but the experience drove the development of this project..

The goal of this investigation is to determine design limitations and architectural solutions that limit the impact light from displays and indicator lamps have on the operational environment task lighting and lighting countermeasure spectrum constraints. It is concerning that this innovative architectural lighting system, could be compromised by spectrums from display systems, architectural materials, and structures that are not considered as part a full system design implementation. The introduction of many Commercial Off the Shelf (COTS) products to the spacecraft volume that contain LEDs, without consideration to the human factors and biological constraints, is another problem. Displays and indicators are a necessary part of the spacecraft and it is the goal of this research project to determine constraints and solutions that allow these systems to be integrated while minimizing how the lighting environment is modified by them.

Due to the potentially broad scope of this endeavor, the project team developed constraints for the evaluation. The evaluation will be on a set of tasks that required significant exposure in the same environment while having a large chance of impacting the light spectrum the crew is expected to receive from the architectural lighting system. The team plans to use recent HRP research on “Net Habitable Volume” [1] to provide the boundary conditions for volume size. A Zemax ® lighting model was developed of a small enclosure that had high intensity overhead lighting and a standard intensity display with LED indicator arrays. The computer model demonstrated a work surface illuminated at a high level by the overhead light source compared to displays and indicators whose light is parallel to the work plane. The overhead lighting oversaturated spectral contributions from the display and indicator at the task work surface. Interestingly, when the observer looked at the displays and LEDs within the small enclosure, their spectral contribution was significant but could be reduced by reflecting overhead light from the wall(s) to the observer. Direct observation of displays and LEDs are an issue because the user’s viewing area is a display, not an illuminated work surface. Since avionics command centers consume significant crew time, the tasks that seemed at higher risk for unwanted spectral contributions as an operational volume with significant quantity of displays and indicators that were either under direct observation of the crew or impacting a volume the crew may be required to sleep in. .

Zemax models of an avionics command console environment within a volume large enough for both the command station and a sleep station will be developed. Additionally, requirements will be developed and a mockup fabricated to evaluate the findings of the model and attempt to provide limitations and solutions to mitigate unwanted light. Allowed changes to spectrum will be driven by spectral constraints for a lighting countermeasure and maintenance of good color accuracy of objects viewed within the environment. Using a combination of computer modeling, and conventional lighting analysis, the goal of this team is to identify solutions including architecture, materials, equipment placement, light source placement, display and indicator colors, display size, indicator quantity and intensity, and technologies that keep unwanted spectrum from displays and indicators at a manageable level.

REFERENCES

[1] Thaxton, Chen, Whitmore; NASA/TM-2014-217386, “2012 Habitable Volume Workshop Results: Technical Products”, *Human Research Program (HRP) Space Human Factors Engineering (SHFE) Portfolio*.