

Conclusive Aircraft Lighting Approach for Reducing Maintenance and Improving Safety

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ABSTRACT

Advanced technologies in LED's have the potential to reduce maintenance and improve aircraft safety.

Aircrafts need adequate illumination for night time landing. New technology such as high-power LEDs allow for better suited light distributions, more whitish light compatible for mesopic lighting conditions and reduced glare in adverse weather conditions. LEDs and the associated electronics are more susceptible to harsh environmental conditions and this needs to be accounted for in the design of the equipment.

Highly conductive metal core PCBs (MCPCB) allow for adequate cooling in a mirror telescopic optical arrangement when coupled with robust active cooling. Closed loop optical feedback of output flux ensures constant performance over the lifetime of the light unit and allows for indication of remaining useful life to the operator to plan maintenance activities. Parylene coating inhibits premature degradation of the LEDs induced by water vapor and corrosive gases.

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INTRODUCTION

Aircraft exterior lights such as beacon, Anti-Collision or Landing lights have a very high photometric intensity - the landing lights can be seen from 160km distance [1], but Pilots do not get the most from today's exterior lighting especially as the light from the landing lights is not sufficiently controlled and not satisfactorily distributed to maximize their vision. In adverse weather conditions such as fog or snow, the pilots might even turn-off the landing or Anti-Collision lights to improve visibility which is in those conditions reduced by self-induced glare. Vision though is considered a key sense and many tragedies such as the Tenerife disaster [2] may have been avoided if the pilots had been able to see each other.

LED lights can enhance visibility through better suited light spectrums in low illumination conditions [3,4]. Optical set-ups such as a mirror telescopic arrangement can collect the emitted light from the LED with high efficiency and shape the light beam in the desired direction without almost any stray light, reducing self-induced glare (fig. 1).

Efficiency is a key element for LED operation, as LEDs are highly susceptible to elevated temperature [5], therefore avoiding heat generation is a priority. Fitting an LED based landing light (fig.2) into the same space envelope as a current filament based light such as the standard 600W PAR64 landing light (8" dia. similar to fig.2) with similar lumen output, can lead

to overheating conditions alone. Exterior lights though have to withstand environmental temperatures of +70°C and additional solar radiation - for the semiconductors, when no airflow is present thermal management is paramount. Forced cooling could improve the heat dissipation and needs to be sufficiently robust to survive on the Nose Landing gear, with the reliability preferably an order of magnitude greater than that of the light sources themselves.

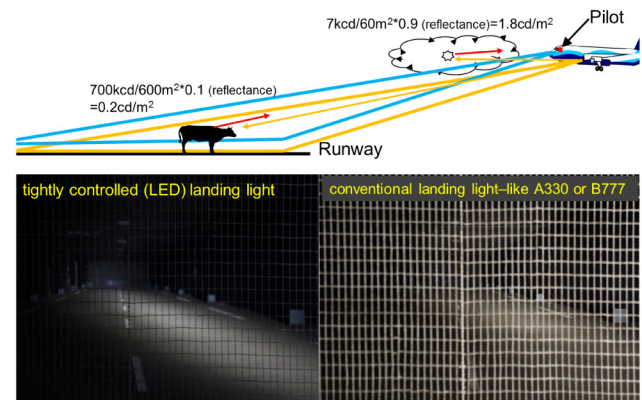


Figure 1. Visualization of self-induced glare in adverse weather in a dark tunnel - using a net in front of the observer reflecting stray light

LEDs rarely fail at once but slowly degrade and shift in color depending on temperature as well as current density. Optical sensors could detect Near-End-Of-Life conditions and indicate to the operators with sufficient lead time that an overhaul of the unit is due.

Another benefit is that closed loop optical monitoring of the flux allows the operating regime of the light sources to be changed, keeping the luminous flux constant.

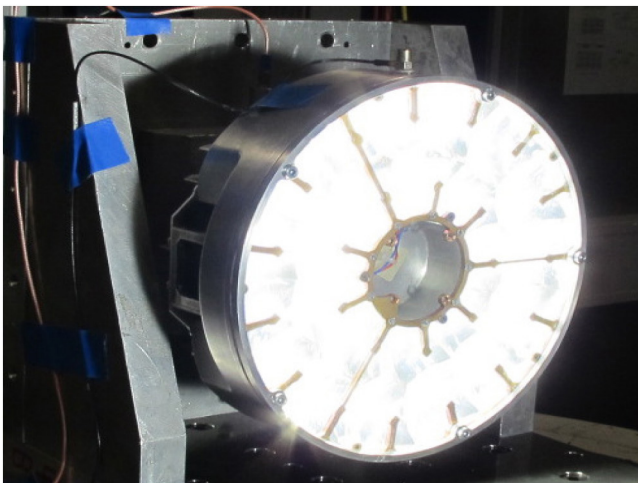


Figure 2. LED Landing light for a commercial Aircraft in mirror telescopic arrangement - mounted on a vibration test fixture

LEDs often have primary optics made from plastic or silicon (fig. 3), which is permeable to water vapor and corrosive gases such as NO_x and SO_x found in exhaust fumes. In a ventilated housing the LEDs have to be protected against these gases to meet the expected useful life [6].

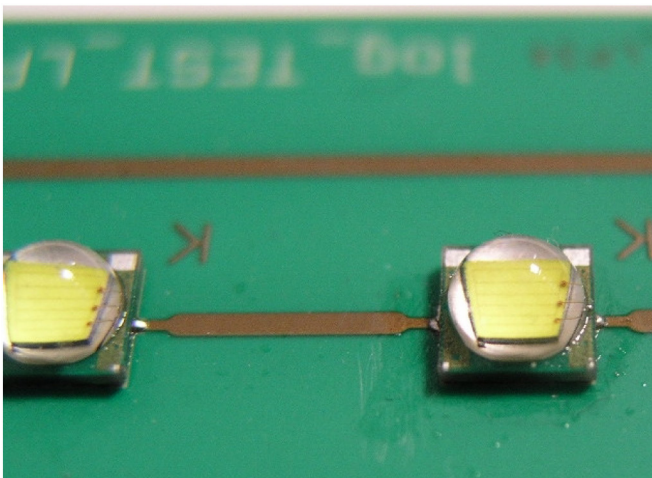


Figure 3. Typical High-Power LED with silicone/plastic primary optics - mounted on MCPCB for endurance testing

It might be beneficial to re-think the performance requirements of some exterior lighting functions. Stray light impairing the pilot's vision is not considered at all today, nor is adequate light to enhance peripheral vision. On the other

hand, the full performance of many exterior lights on a hot soak day is hardly needed when the solar radiation dominates by orders of magnitude.

LED EXTERIOR LIGHTING ASPECTS

Most airports are well illuminated and the light pollution in densely populated areas is often so high that e.g. landing lights are not needed at all. Under these conditions the pilots turn everything "on", not to see, but to be seen. However in emergency situations and remote and unknown landing strips, the landing lights become vital. The FAR and EASA-CS have few requirements i.e. providing "enough" light for night time landing and not emit objectionable glare or halation [8]. The SAE ARP goes further and suggests some values for the photometric performance, which are in line with the available light sources outlined in the document at the time of publication.

Good perception of the surroundings, especially in adverse weather like snow, is less dependent on peak intensity, or distribution width, it is dependent on the absence of light crossing the pilot's line of sight. Depending on the distance of stray light crossing the pilots line of sight, the intensity ratio has to be 3 to 4 orders of magnitude lower than the average landing light intensity in order to achieve a signal to noise ratio of 50:50 with an obstacle like a herd of deer at 400m distance, as can be easily calculated via the square distance equation and the reflectance of the objects(fig.1).



Figure 4. HID Landing Lights simulating "approach" conditions for test pilot evaluation. Fwd lift (RH side) hosting represents Flight Deck. Notice the amount of stray light illuminating this area

The three building blocks of efficient illumination have to be considered common sense: 1) No light crossing in front of the pilots, as otherwise the vision in clouds and snow may be reduces to almost zero 2) The luminosity should be uniform, with no hot and dark areas that may mislead perception. 3) Light is only needed in directions that are visible through the flight deck windows.