Military aircraft: LED lights for high-speed take-offs, landing, and taxi

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Abstract: *This paper presents the authors' recent documentary research on the benefits of using LED lighting products for military aircraft for high-speed take-offs, landings, and taxiing. LED lighting products offer numerous advantages over conventional incandescent aircraft bulb lighting (Halogen and Xenon bulb-based lighting technologies). In terms of energy consumption, LED lighting products are ten times more efficient than incandescent lighting, designed and produced to consume much less electricity than conventional lighting, and do not require a high voltage external power supply. LED lights maintain their full light output even at lower aircraft engine rotation. The LED lights are solid-state mounted devices that can tolerate high levels of shock and vibration without failing. The LED lights for high-speed take-offs, landings, and taxiing offer extraordinary performance that will truly transform the flying experience during nighttime.*

Key Words: *LED, LED lights, high-speed take-off, landing, taxi, military aircraft*

1. INTRODUCTION

LED means light-emitting diode. In the electronic field, it is a semiconductor device that emits light when charged with an electric current, without producing heat. The LED was invented and improved successively by H. J. Round (1907); Oleg Losev (1927); James R. Biard (1961); and Nick Holonyak (1962) [7]. The first LED production occurred in October 1962 with anode and cathode as a pin configuration, using electroluminescence as a working principle. From 1962 to the present day, the production of LED lighting has seen very rapid development, especially due to the economy of electricity that their use brings to a world increasingly concerned about energy saving. Light-emitting diode (LED) is right now the most energy-efficient lighting technology available, and it is only natural that it is also one of the most rapidly-developing technologies [4].

LED is solid-state lighting (no moving parts and no gas inside) where a semiconductor converts electricity to light usually in a very small area, less than one square millimeter or less, so as in an LED lamp, there are multiple light-emitting diodes [1].

The light generated is projected in one direction, which does away with using diffusers and reflectors [8]. Military aircraft LED lighting products for high-speed take-offs, landings and taxiing offer numerous advantages over previous conventional Halogen or Xenon bulb-based aircraft lighting technologies. From the point of view of energy consumption, LED

lighting products are ten times more efficient than incandescent lighting. They are designed and produced to consume much less current than conventional incandescent lighting and require no external high voltage power supply. LED lights maintain their full light output even at lower aircraft engine rotation [6].

The LED lights are solid-state mounted devices that can tolerate high levels of shock and vibration without failing [6]. The LED lights for high-speed take-offs, landings, and taxiing offer extraordinary performance that will truly transform the flying experience during nighttime for any military aircraft.

2. ADVANTAGES OF USING LED LIGHTS

Military aircraft LED Lighting technology offers numerous advantages over conventional incandescent aircraft lighting (Halogen and Xenon bulb-based lighting technologies). LED Lighting technologies directly convert electricity into light, are ten times more efficient than incandescent, draw far less current than conventional lighting, and require no external hi-voltage power supply, without producing heat.

- LED Lighting turns on immediately, dissipate the minimal heat, and is unaffected by the number of turning the switch on/off.
- LED Lighting provides light even at a low rotational speed of the aircraft engine (revolutions per minute), which is critical for landing configuration.
- LED Lighting is solid-state and is vibration and shock very resistant.
- The proper electrical design allows LED Lighting products to easily last over 30,000 - 50,000 hours in continuous operation, eliminating the cost of frequent lighting lamp replacements specific for incandescent aircraft lighting lamps [6].
- LED Lighting installations are once done and do not require other interventions during their entire lifespan.

The advantages of using LED Lighting are highlighted for the above reason, as shown in Figure 1 and the following explanations [6].

The average incandescent bulb lasts about 100 hours in the aircraft environment. The lifespan of an average LED light is 50,000 hours. Depending on the environmental conditions, its life may be as long as 100,000 hours [6]. LED Lighting can light up in any aircraft environment for six to twelve years before replacing it.

When integrated into a well-designed lighting system with adequate heat sinking [2] and solid-state mounting, **LED-based lighting products will easily last over 50,000 hours of continuous operation**. Unlike most other light sources, **LED lights do not have their lifespan reduced by the number of on/off cycles**. LED Lighting products are designed to keep the LED junction temperatures well below their maximum rated values to ensure that the manufacturer's rated life projections are achieved, and all **LEDs are hard mounted to avoid stress failures** [6].

The LEDs used in LED Lighting products have **high lumen efficacy ratings**, and as a result the products typically use less than a third of the power of halogen bulbs. This significantly **reduces the electrical load** on the airplane's battery and alternator system. On the final approach for landing, the low rotational speed of the aircraft engine (revolutions per minute) results in reduced output from the alternator, so halogen bulbs typically overload the electrical system and produce less than their rated light output at full voltage [6]. **LED lights maintain their full light output even at lower battery voltages**. LED lighting produces less waste light and more useful lumens than any other lighting technology [1].

The **LED Lighting has improved environmental performance**. The environmental benefits of LED lighting also extend to their manufacturing process and the recycling process when they reach the end of their lifespans because they do not use any polluting compounds [3].

The LED Lighting is a solid-state-mounted device that **can tolerate high levels of shock and vibration without failing** [6]. Airframe vibration is the primary driver of Halogen bulb filament failures and Xenon tube lead failures. The LED lights are designed to tolerate indefinitely this high vibration environment [8].

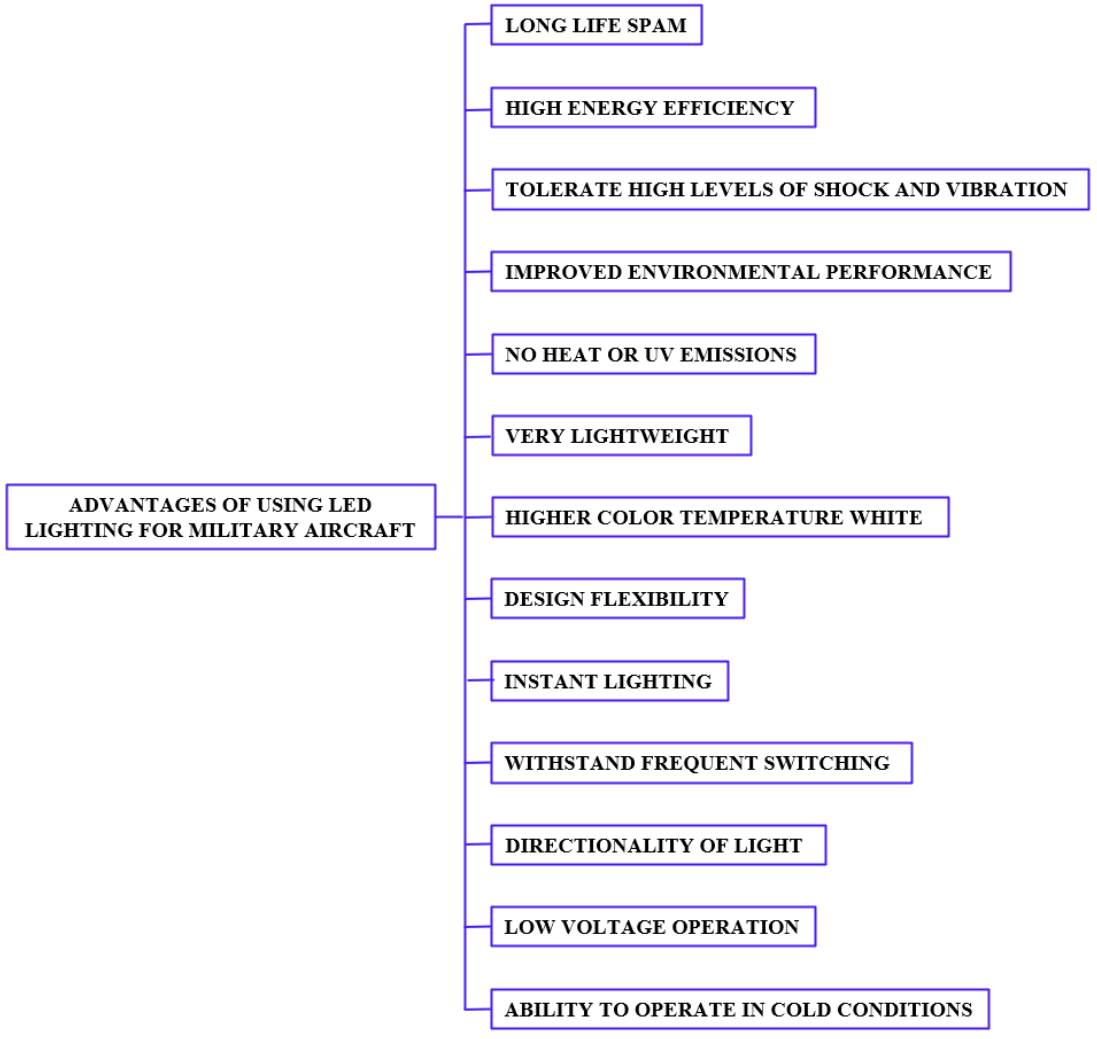

Fig. 1 Advantages of using LED Lighting for military aircraft

LED Lighting products utilize built-in power supplies and **are very lightweight**. Traditional incandescent products utilize large, heavy power supply boxes [6].

What makes LED lights the best for military airplanes and military drones is that **they have 6500K, sunlight equivalent, colour temperature, designed for superior visibility** compared to yellower incandescent sources (Halogen and Xenon bulb-based lighting technologies) [6]. The higher colour temperature light stimulates all of the cones in the fovea of the human eye, which is the area of the eye that provides the highest resolution vision.

6500K is also superior for air-to-air recognition since it looks like sunlight reflected by a mirror, whereas yellower light sources do not attract as much attention [9].

LEDs are very small, less than one square millimeter, and this means that they **can be used in almost any lighting application**. LED lights offer design flexibility and various types: Dual In-Line Package - **DIP LEDs**, Surface Mounted Diode - **SMD LEDs**, and Chip on Board - **COB LEDs**.

The LED Lighting is a solid-state-mounted device that **can tolerate high levels of shock and vibration without failing** [6]. Airframe vibration is the primary driver of Halogen bulb filament failures and Xenon tube lead failures [8]. **LED lights are designed to indefinitely tolerate this high vibration environment** [9].

Many traditional lighting sources like incandescent bulbs turn more than 90% of the energy they use to heat, allocating only 10% of energy to actual light production while **LED lighting emits almost no heat** [10].

Conventional lighting technology emits light at 360° around the light source, but an LED light only lights up an area of 180°, so it is a **directionality of lighting** [1].

Figure 2 presents several comparative images of the runway between LED lighting (left) and incandescent lighting (right) [6].

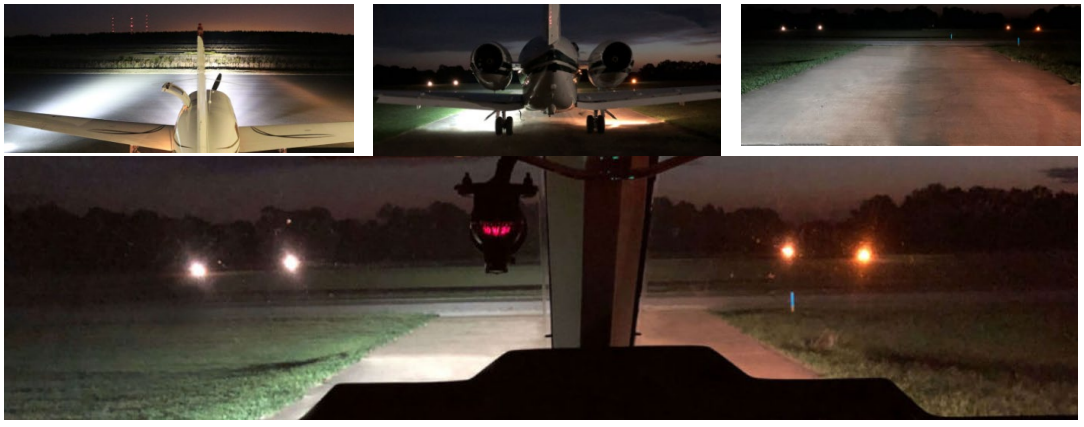

Fig. 2 Runway view LED lighting (left) vs. incandescent lighting (right) [6]

Given all the advantages listed above, the authors highly recommend replacing all incandescent lamps with modern, highly energy-efficient, and certified LED lights for all military aircraft.

3. LED LIGHTS FOR HIGH-SPEED TAKE-OFFS, LANDING, AND TAXI

All the new military aircraft will be designed with modern, and highly energy-efficient LED lamps, based on numerous advantages over conventional incandescent aircraft lighting. Figure 3 presents the LED package, which consists of an outer package that contains a LED chip mounted usually on a silicon substrate or die-attach, which is again mounted on a thermal heat sink slug and a hard lens on the top-side of the LED package to protect it from damage and shaped to produce a specific viewing angle.

The LED chip's bottom side connected to the surmount is called the LED junction. LED packages can be mounted in series as well as in parallel e.g. on printed circuit boards to create a LED array.

Light is produced on the top side of LED chips, whereas dissipating heat is produced on the bottom side of the chips, named the LED junction area.

The performance, reliability, efficiency, and lifetime of LED chips are strongly related to the junction temperature of the chips [2]. In general, it is recommended to keep the junction below 120°C to run the LEDs for a maximum lifetime [11].

Exceeding the maximum operating temperature specification, which is typically 150°C junction temperature, can cause permanent damage to LEDs [11].

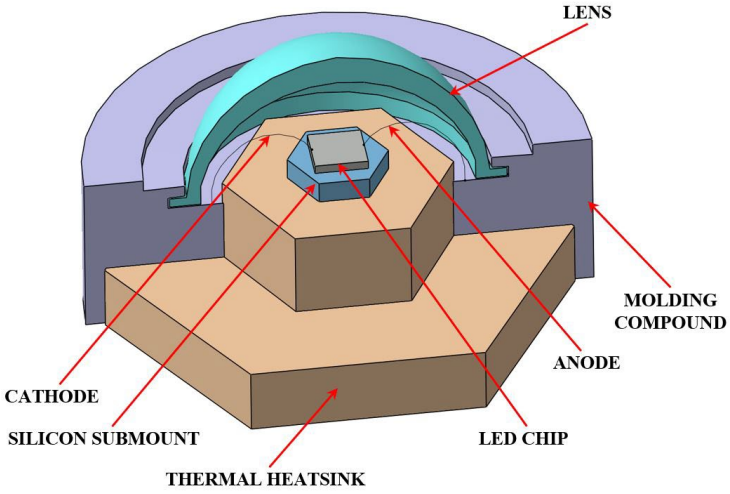

Fig. 3 Typical LED package

Figure 4 presents a military aircraft with the basic LED lights for high-speed take-offs, landings, and taxiing.

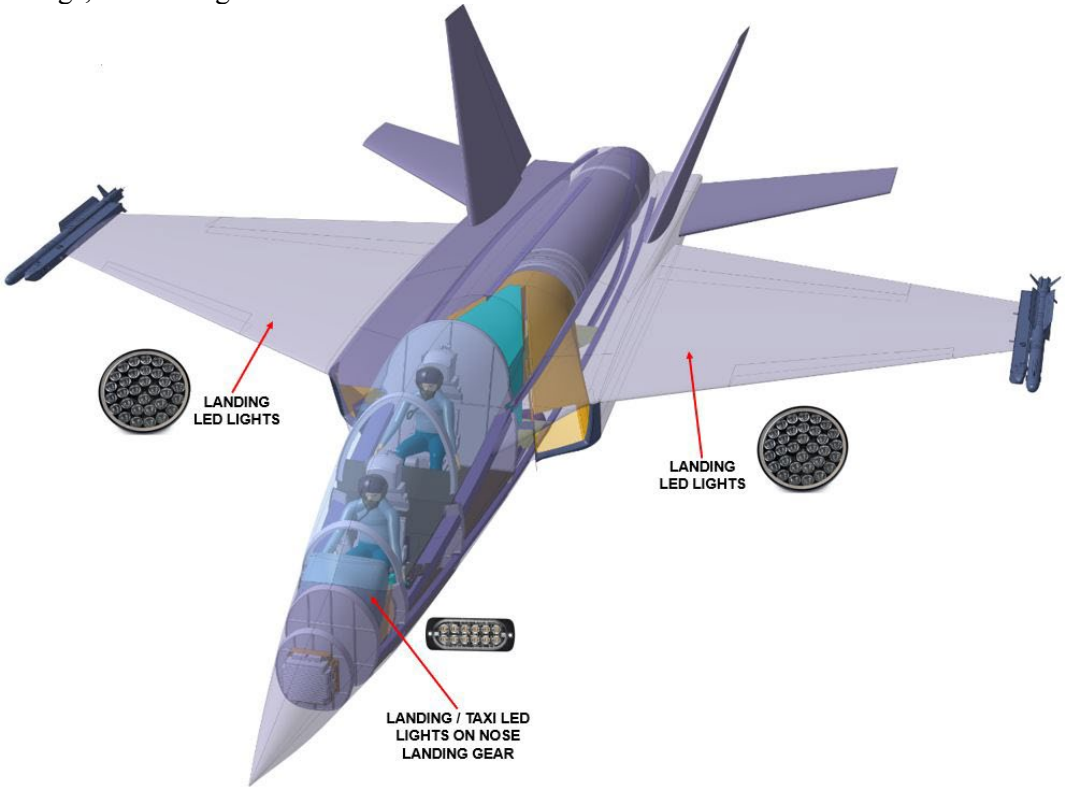

Fig. 4 Military aircraft: LED lights for high-speed take-offs, landing, and taxi

When we choose or evaluate LED light it is important to know the two important parameters of any LED lamp: lumens and candela.

Lumens are the total amount of light output, and candela is the concentration of projected light within a given volume [6].

Adding more lumens increases the total amount of light, but the candela remains constant. As the area of light distribution decreases, candela increases [6].

High candela alone does not make a good landing light, just a good marketing number. A 0.5-milliwatt pocket laser pointer is around 2 million candelas compared to a bare 100W incandescent bulb, which is 300 candelas [6]. Both lumens and candela are equally important.

A good landing light needs enough lumens for the pilot to have a peripheral vision of the runway and enough candela to see far down the runway. LED lights provide an optimum balance between lumens and candela [6].

Based on numerous advantages over conventional incandescent aircraft lighting, LED lamps are increasingly used in the new designed military aircraft, like LED switch illumination, LED lighting in the cockpit, LED mini floodlights, LED navigation lights, Tri-Mode (Red/White/IR) Anti-Collision Lights, LED Taillights, etc., as shown in Figure 5.

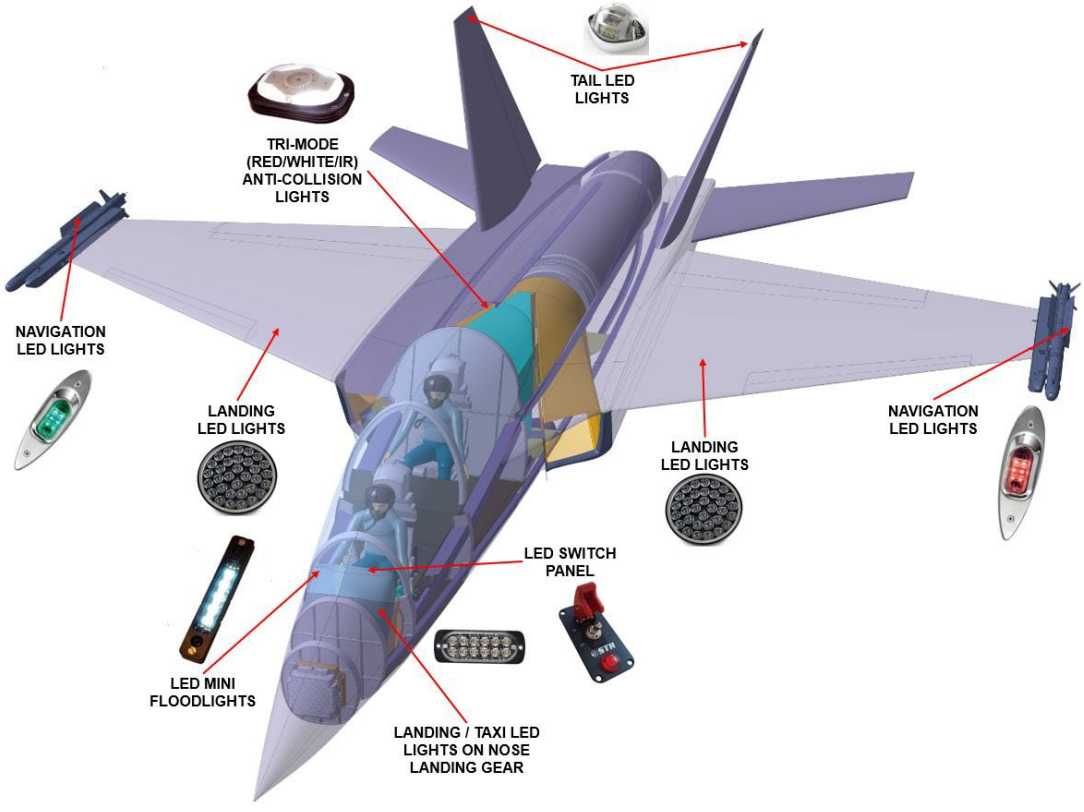

Fig. 5 Other uses of LED lights for military aircraft

One more time, the authors highly recommend using LED lights for all new military aircraft, and replacing all incandescent lamps with modern, highly energy-efficient, and certified LED lights for all old military aircraft when these aircraft enter the modernization process.

4. CONCLUSIONS

Light-emitting diode (LED) is right now the most energy-efficient lighting technology available, and it is only natural that it is also one of the most rapidly developing technologies. LED is solid-state lighting where a semiconductor converts electricity to light usually in a very small area, less than one square millimeter, so as in an LED lamp, there are multiple light-emitting diodes.

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