Integration of OLED Lighting in Aircraft

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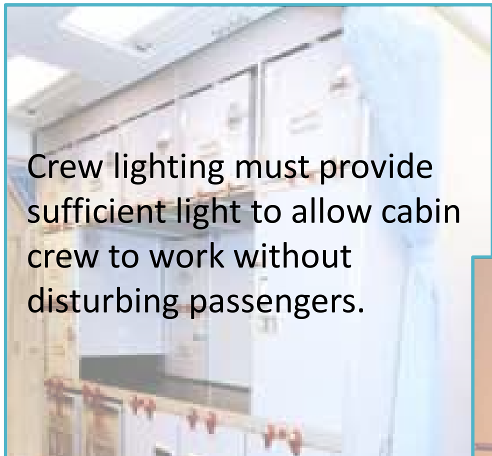
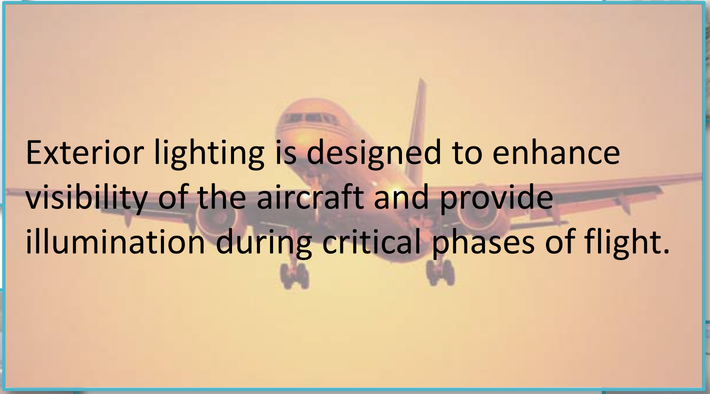
January 31, 2018

Aircraft lighting serves many different functions, each with unique requirements based on the operating environment and Development Assurance Level (DAL)





SAE ARP4754 Provides guidance for performing safety assessments and determining DAL of a given system

TABLE 2 - TOP-LEVEL FUNCTION FDAL ASSIGNMENT

Top-Level Failure Condition Severity Classification	Associated Top-Level Function FDAL Assignment
Catastrophic	A
Hazardous/Severe Major	B
Major	C
Minor	D
No Safety Effect	E

Source: SAE ARP4754A Guidelines for Development of Civil Aircraft and Systems

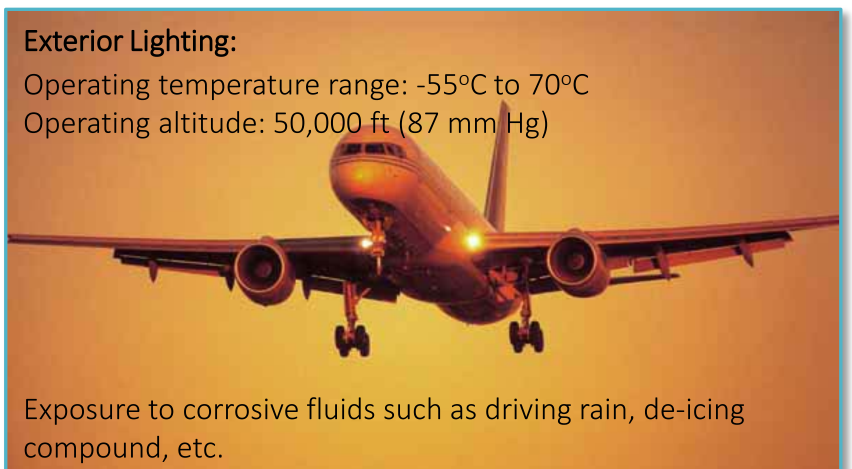
As defined in the FAA and EASA guidance (AC 25.1309A/AMC 25.1309):

- *Catastrophic:* Failure Conditions, which would result in multiple fatalities, usually with the loss of the airplane. (Note: A "Catastrophic" Failure Condition was defined in previous versions of the rule and advisory material as a Failure Condition which would prevent continued safe flight and landing.)
- *Hazardous:* Failure Conditions, which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions, to the extent that there would be:
  - A large reduction in safety margins or functional capabilities;
  - Physical distress or excessive workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or
  - Serious or fatal injury to a relatively small number of occupants other than the flight crew.
- *Major:* Failure Conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be, for example, a significant reduction in safety margins or functional capabilities, a significant increase in crew workload or in conditions impairing crew efficiency, or discomfort to the flight crew, or physical distress to passengers or cabin crew, possibly including injuries.
- *Minor:* Failure Conditions which would not significantly reduce airplane safety, and which involve crew actions that are well within their capabilities. Minor Failure Conditions may include, for example, a slight reduction in safety margins of functional capabilities, a slight increase in crew workload, such as routine flight plan changes, or some physical discomfort to passengers or cabin crew.
- *No Safety Effect:* Failure Condition that would have no effect on safety; for example, Failure Conditions that would not effect the operational capability or the airplane or increase crew workload.

RTCA DO-160 Defines test conditions used to substantiate performance based on operating environment and DAL

- Will the be part installed in a temperature, altitude, and/or humidity controlled environment?
- Will the be part installed in a flammability zone?
- Will the be part be installed in a designated lightning zone?
- How critical is the part to flight operations?

Answers to these questions help match parts according to the test categories described in the DO-160 for temperature, vibration, electromagnetic effects, fluid susceptibility, flammability, etc.



Flight Deck Displays:

Must meet the most stringent EME susceptibility thresholds for AF, RF , and lightning induced transients.

Performance requirements are also driven by customer defined needs

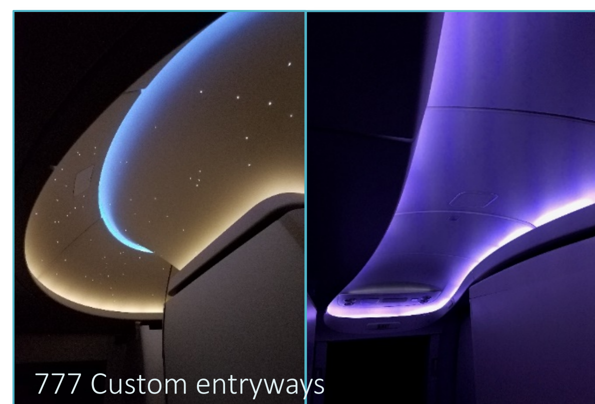
Current airplane programs offer color-tunable lighting systems, which airlines utilize to create custom lighting scenes

Airlines may further customize their interior through feature architecture and accent lighting

As a critical component of airline branding, cabin lighting systems are subject to intense scrutiny, resulting in strict color and luminance requirements


787 Color-tunable lighting


777 Starry skies


777 Custom entryways

Stability and reliability is required of all aircraft components

Change is difficult due to the time and effort involved in qualification

A modification of the form, fit, or function results in creation of a new part and further qualification

Obsolescence of materials and electronic components is a major concern

Increased reliability as measured by Mean-Time Between Failure (MTBF) and Mean-Time Between Unscheduled Removal (MTBUR) is desirable to reduce maintenance costs

Many parts are designed for a 20 year service life

Any replacement lighting system must offer the same performance as current systems

Current LED-based general lighting systems offer airlines the opportunity to customize their flight experience through programmable lighting scenes

If functional performance is comparable, the new system must offer improved economics to warrant a change

Unique functionality above and beyond the current system may be enough to overcome economic shortcomings and justify a change

Boeing is tackling the challenge with targeted technology insertions

Identify applications with the lowest barrier to entry (e.g., stable environmental conditions, non-essential equipment, ease of integration, etc.)

Capitalize on commercially available technology, where possible, to reduce development costs

Amass some “quick wins” to demonstrate technical maturity

Expand technology utilization based on development and in-service experience

Potential aerospace applications based on patent filings

COTS equipment in non-essential applications

COTS equipment in essential applications

Aerospace unique products

Utilization in extreme environments

OLED implementation

Interior lighting applications that result in "No Safety Effect" in the event of failure

Information display

US Patent 8,260,545 Methods and apparatus for generating a navigation chart

OLED lighting embedded in structural panels

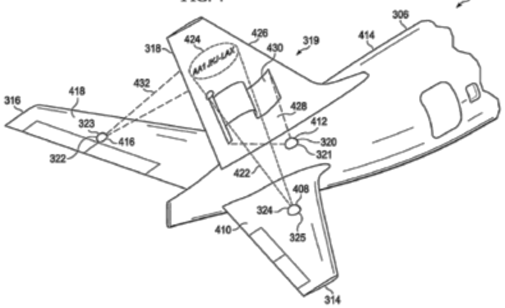
US Patent 7,857,484 Lighting panels including embedded illumination devices and methods of making such panels

US Patent 8,033,684 Starry sky lighting panels

Virtual livery

US Patent 8,651,664 Aircraft projector system and movement detection system responsive to aircraft structure movement

FIG. 4



OLEDs have many perceived advantages, but more investigation if required to meet aerospace needs

Large area diffuse light – no concentrated heat loads

Light-weight, thin, conformable, and flexible – easily adapts to a variety of surfaces and installation locations

Utilize small molecule or polymer materials – chemistry can be easily manipulated to achieved desired result

Roll-to-roll manufacturing possible – inexpensive, large-scale production

Large-scale implementation requires improvements in reliability, reduced cost, and a robust obsolescence strategy