Aerospace Applications for OLED Lighting

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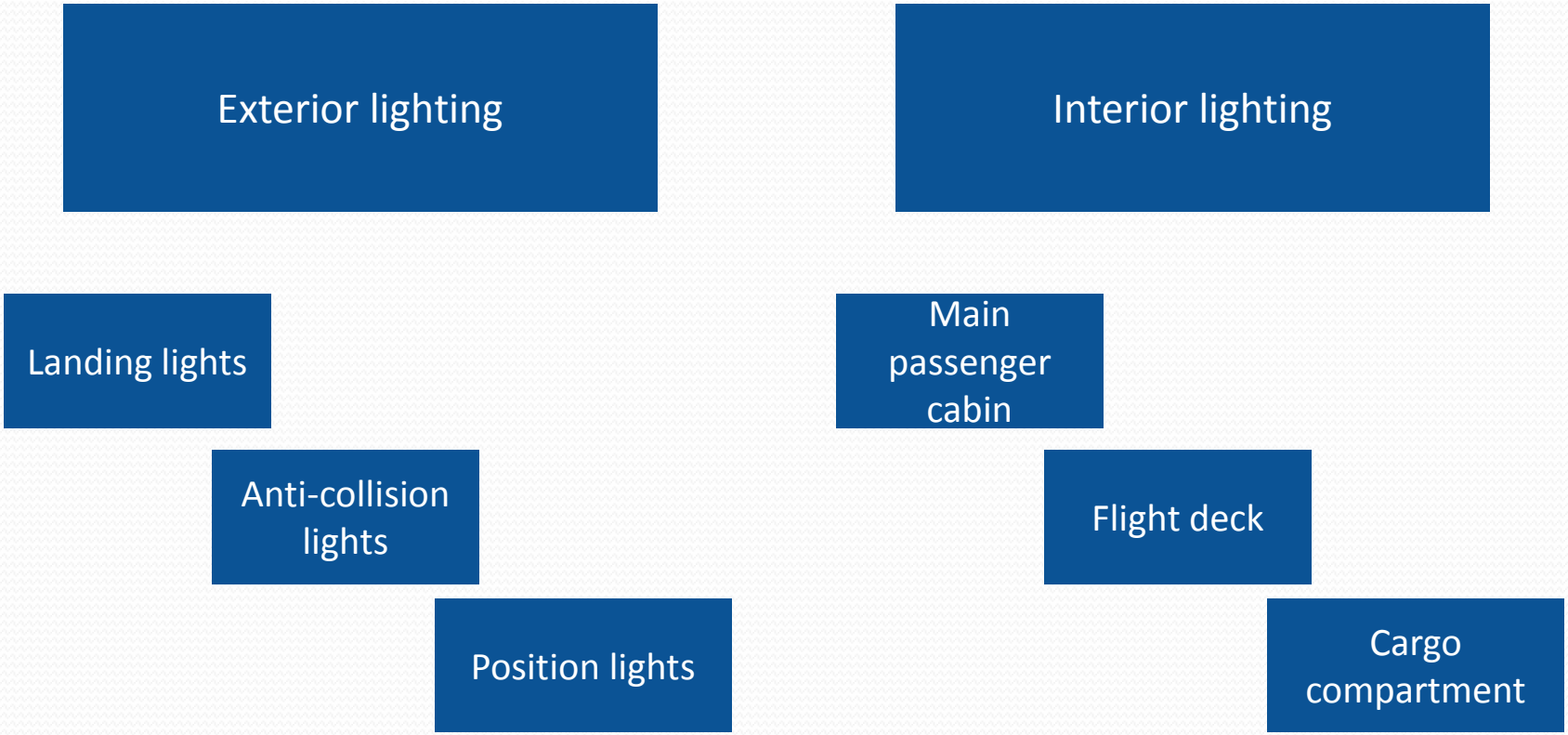
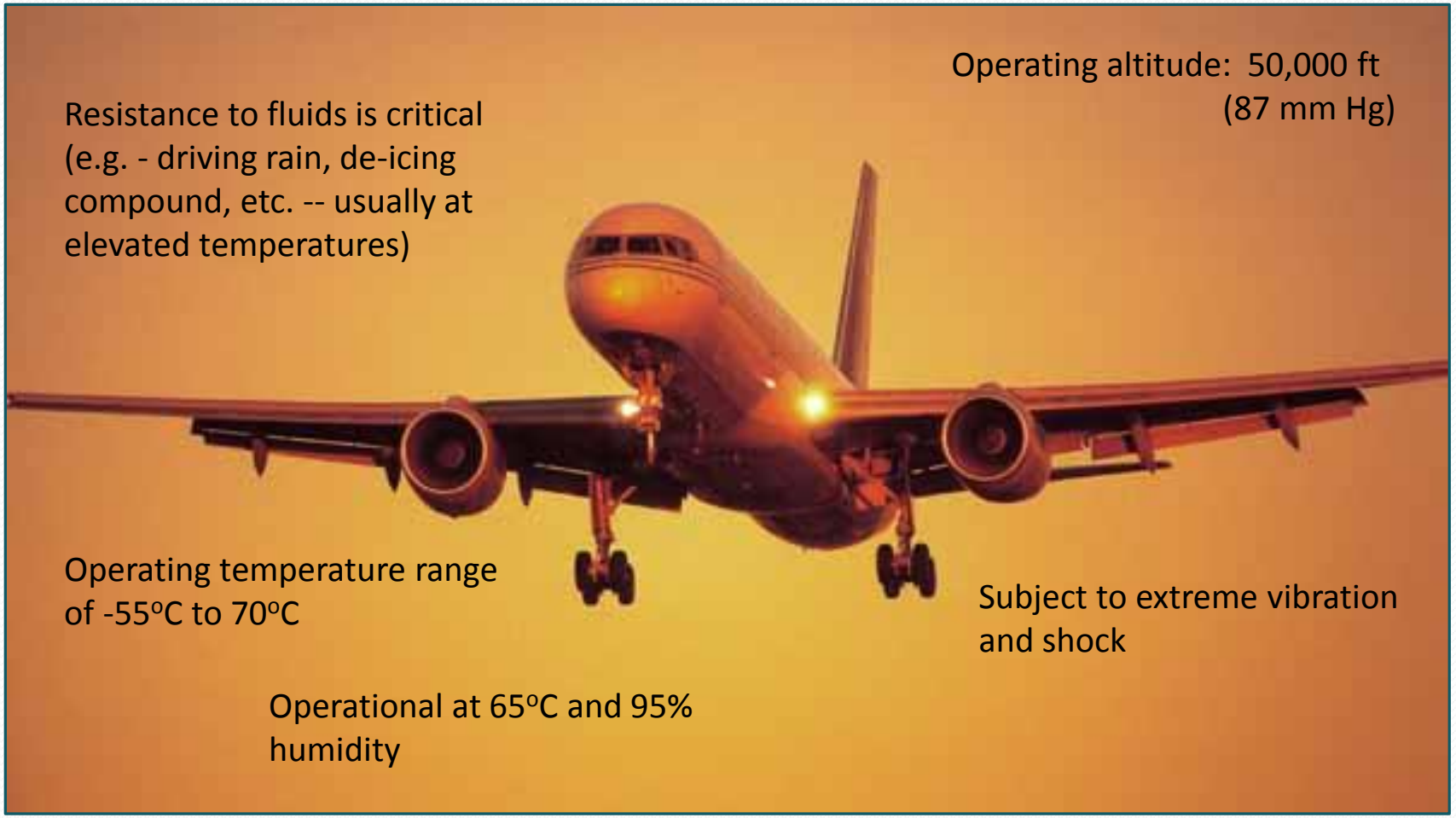
- **Commercial Aerospace Lighting**
- A Brief History of Solid-State Lighting at Boeing
- Aerospace Lighting Requirements
- Potential Uses for OLEDs

Lighting is divided into two major disciplines



Exterior lighting components are subject to extreme conditions and require high reliability



Interior lighting components serve a wide range of purposes

Flight deck

- General illumination
- Task lighting
- Indicator lights

Cargo compartment

- General illumination
- Indicator lights

Main passenger cabin

- General illumination
- Task lighting
- Indicator lights
- Lighted signs
- Accent lighting
- Emergency lighting

Flight deck lighting is all about performance

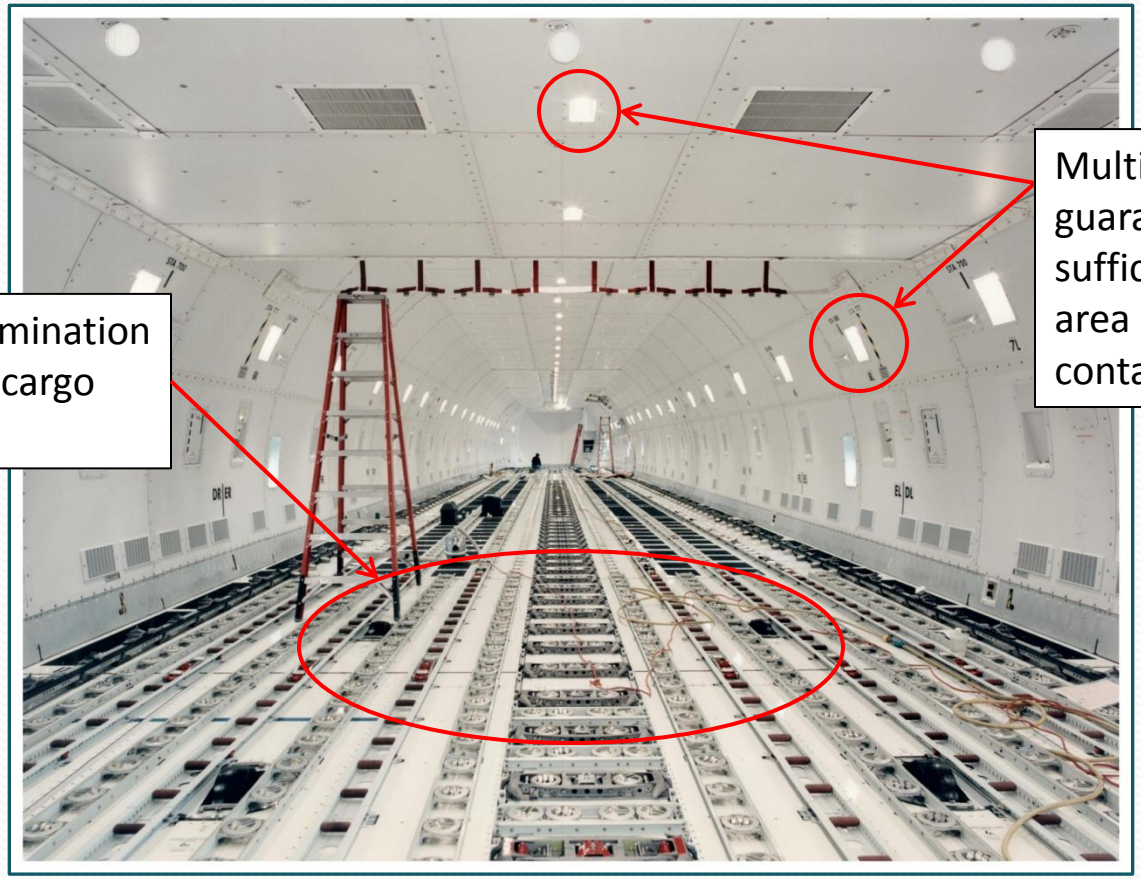
General illumination is unobtrusive

Task lighting is designed to control glare while still increasing the amount of light in critical areas

Indicator lights to convey information and status

All flight deck lighting is designed to improve information delivery, eliminate distractions and enhance pilot performance.

Cargo lighting is all about function



Goal is even illumination throughout the cargo compartment

Multiple sources guarantee there is sufficient light as cargo area is filled with containers

Cargo/freighter lighting is designed to maximize light output and efficiency.

Main cabin lighting must serve a dual purpose – meeting the needs of the crew and passengers

Crew lighting is functional and must provide sufficient light to allow cabin crew to work without disturbing passengers

Passenger lighting must satisfy multiple needs simultaneously – work, relaxation sleep, etc.

The airlines drive additional requirements to satisfy their branding and marketing needs

Airlines can customize their interior cabins through accent lighting

Current production airplanes offer color-tunable lighting systems

Many airlines choose to take advantage of the system capabilities and create custom lighting scenes.

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LED Timeline

2001 LED signs and indicator lights are introduced into the passenger cabin

2003 777 program implements a “hybrid” fluorescent-LED general lighting systems

2004 Boeing launches 787 program, the first airplane designed with an all LED lighting system

Soon after Boeing commits to expansion of LED lighting with the launch of the 747-8I and 737 Boeing Sky Interior


777 Hybrid System


787 LED System


747-8 LED System


737 Boeing Sky Interior

LED Timeline

2010 Boeing delivers first 737 Boeing Sky Interior to flydubai

2011 Boeing delivers first 787 to All Nippon Airways

2012 Boeing delivers first 747-8I to Lufthansa

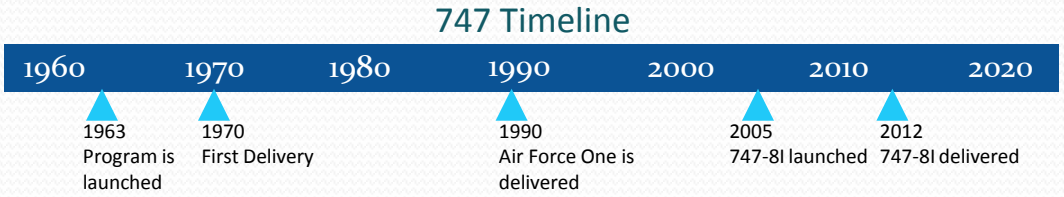
2012 Boeing replaces 777 hybrid lighting system with an all LED lighting system

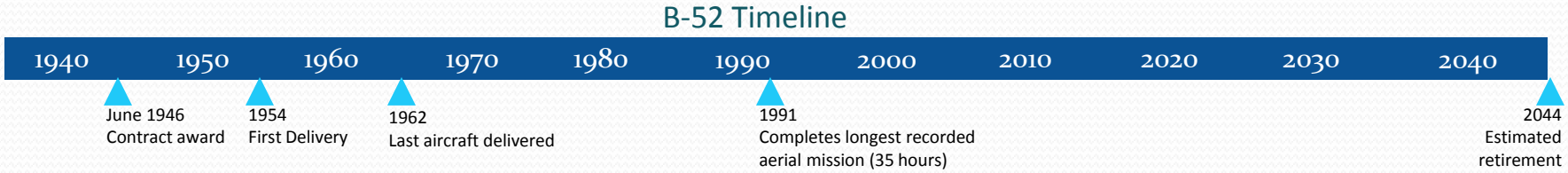
2013 777X program is launched with the promise of an all new lighting system

Implementation of LED lighting on commercial programs facilitated LED use on KC-46A tanker and CST-100 platforms

Aerospace economics drive long development cycles and even longer product lifecycles

- Development of a new airplane or major derivative is approximately 7 years
- The 747 has been in production for more than 45 years
- Individual aircraft (such as Air Force One) have been in service for decades





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Qualification of aircraft components is heavily regulated and expensive

- Qualification is controlled by a combination of government regulations, industry standards and internal requirements
- Lighting specific qualification is governed by the following:
  - **FAR 25.812**
    Emergency lighting
  - **FAR 25.853**
    Compartment interiors (flammability)
  - **FAR 25.1309**
    Equipment, systems, and installations
  - **FAR 25.1701 – 25.1721**
    EWIS (Electrical Wiring Interconnect Systems)
  - **DO-160**
    Environmental Conditions and Test Procedures for Airborne Equipment
  - **DO-254**
    Design Assurance Guidance for Airborne Electronic Hardware
  - **IEC 62471**
    Photobiological Safety of Lamps and Lamp Systems
  - Boeing specific requirements for restricted materials, smoke density and toxicity, and personal hazard

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 MTBF and MTBUR is desirable to reduce maintenance costs
- Many parts are designed for a 20 year service life

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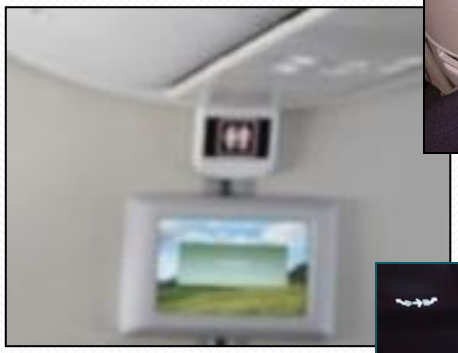
OLEDs have many perceived advantages

- 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

Introducing the new Boeing 777X

Interest in OLED technology for the aircraft is very high across a range of applications

- Lightweight displays for flight deck and passenger cabin
- Smart signs
- Dynamic cabin lighting



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