NSRP Panel Project PP 24-22

[ATI CONTRACT 2019-477-005]

LIGHTING ON NAVAL SHIPS
DOD-HDBK-289(SH) MODERNIZATION SUPPORT EFFORT

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Team Members:

- NAVSEA 05Z33
- SUPSHIP GC
- Ingalls Shipbuilding
- Newport News Shipbuilding
- Austal USA
- PSU ARL EMC
- Phoenix Lighting
- Signal Mate
- *Carlisle & Finch*
- *LopoLight*
- *The L.C. Doane Co.*

TABLE OF CONTENTS

- PROJECTS HISTORY
- PROBLEM STATEMENT & SOLUTION
- PROJECT OBJECTIVES
- PROJECT PROGRESS
- LIGHTING TECHNOLOGIES
- TUTORIALS
- ADDITIONAL CONSIDERATIONS

PROJECT 1 HISTORY - 2020 ADVANCED TOPSIDE LIGHTING SYSTEM

(Panel Project 2019-477-002)

OBJECTIVE

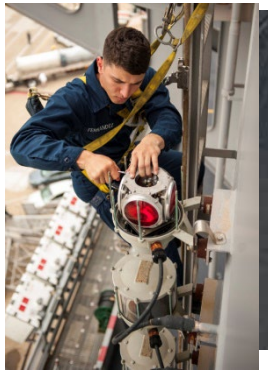
Identify issues with U.S. Navy lighting, define functional requirements, identify new lighting technologies, and outline optimal system.

TEAM:

RSL Fiber Systems | Signal Mate, PSU EOC, Austal, NNS, Ingalls, NAVSEA 05Z33

PROBLEM(s) STATEMENT

- **Corrosion: #1 problem**,
- High Maintenance, Large Size / Weight / RCS, EMI / RFI.
- Multiple control panels required.
- No "One size Fits All" solution.

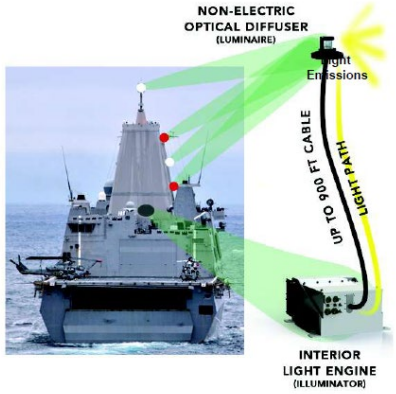


SOLUTION

- Utilize Commercially available advanced solid-state based lighting systems.

BENEFITS / ROI

1. Extend reliable service lifetime.
2. Corrosion mitigation.
3. Reduce TOC.
4. Small size/weight – Reduced RCS.
5. Parts commonality and interchangeability.



PROJECT 1 HISTORY - 2020 ADVANCED TOPSIDE LIGHTING SYSTEM

(Panel Project 2019-477-002)

KEY FINDINGS

1. **Water gets into everything** – *especially when parts are opened for maintenance* → Reduce/eliminate maintenance. Hermetically seal topside equipment.
2. **All metals corrode** – *even 316 stainless steel* → Reduce use of metals topside.
3. **All electrical parts exposed to the weather corrode** → Place electrical parts internal to the ship.
4. **Smaller and lighter is better** → Ease of installation, low RCS, low topside weight.
5. **Damage is inevitable** → Ease of field repairs and modular constructions.

Other Issues / Concerns

6. Damage due to location.
7. Effect of EMI/RFI on LED lights.
8. De-Icing.
9. NVIS Compatibility.
10. Legacy control panels incompatible with LED upgrades.

Photos Courtesy of Austal USA

PROJECT 2 - DOD-HDBK-289(SH) MODERNIZATION SUPPORT EFFORT (Panel Project 2019-477-005)

OBJECTIVE

Support NAVSEA 05Z33 to modernize U.S. Navy lighting.

PROBLEM(s) STATEMENT

- **Outdated / Obsolete: DOD-HDBK-289(SH) Last Revised November 1986.**
- Challenges of retrofitting new technologies into legacy systems.
- ***Modern threats not addressed.***

SOLUTION

- Define FUNCTIONAL REQUIREMENTS and create PERFORMANCE SPECIFICATION.
- Evaluate new, advanced lighting technologies to meet FUNCTIONAL REQUIREMENTS.
- Create recommendations to revise DOD-HDBK-289(SH) and evolve into **MIL-STD-x743**.

ESTIMATED ROI

- **$ 1 M/year on CVN and $ 500K/year on DDG 51** (NAVSEA 05Z33 estimates for nav & signaling)

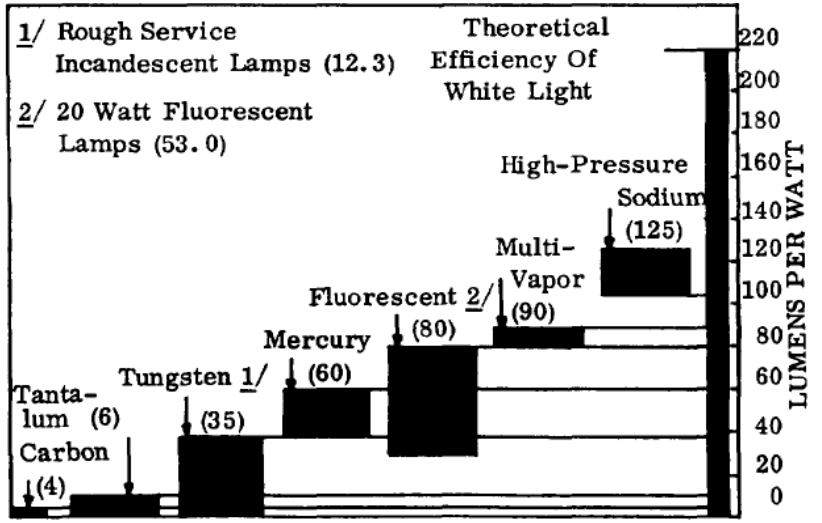


FIGURE 29. Light source efficiency in lumens per watt.

MIL-STD-x743 PROJECT OBJECTIVES

- Support creation of MIL-STD-x743 Document
  - To be referenced in ship design documents.
  - Performance vs. detailed design specifications.
  - Tutorials in appendices.
  - Shipbuilder to determine products / technologies to meet performance.
- Include advanced lighting technologies.
  - Light Emitting Diodes (LEDs).
  - Laser Diodes (LDs).
  - Fiber optic remote source lighting (RSL).
  - *Laser Excited Phosphor (LEP).*
  - *Organic LEDs (OLEDs).*
- Considerations for other ship systems/requirements.
  - Electromagnetic Interference (EMI).
  - Low Radar Coss Section (RCS).
  - Night Vision Imaging Systems (NVIS) aided operations.
  - Interference with Intelligence, Surveillance, Target Acquisition, and Reconnaissance (ISTAR) devices.
  - Susceptibility to High-Altitude Electromagnetic Pulse (HEMP).

MIL-STD-x743 PROJECT PROGRESS

✓ Identified HDBK functional requirements.
- DOD-HDBK-289 Tables XXI, XXII, and XXIII (Navigation, Signaling, and Signal lights) APPLICABLE to MIL-STD-x743.
- Sections of HDBK detailing lighting technologies are OBSOLETE.

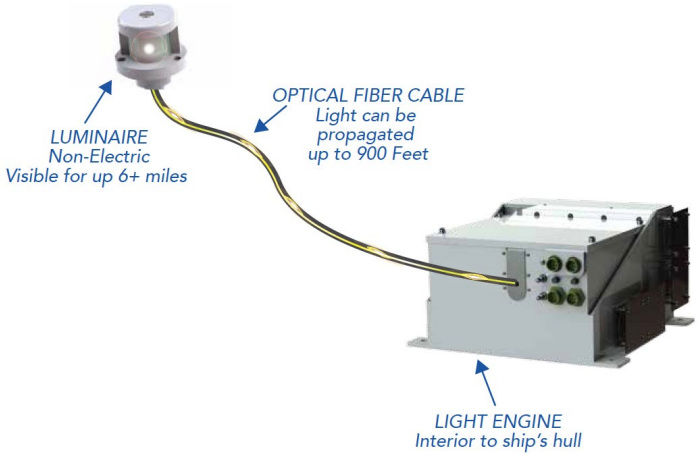
✓ Determined lighting groups to focus on.
- Exterior and interior lights.
- Identified requirements based on advances in ships's systems and future requirements.

✓ Identified differences in New vs. Legacy.
- Generated Tutorial with new lighting technologies.
  - Description of SSL sources.
  - Differences in failure modes.
  - EMI mitigation.
  - Outlined SSL system configuration.

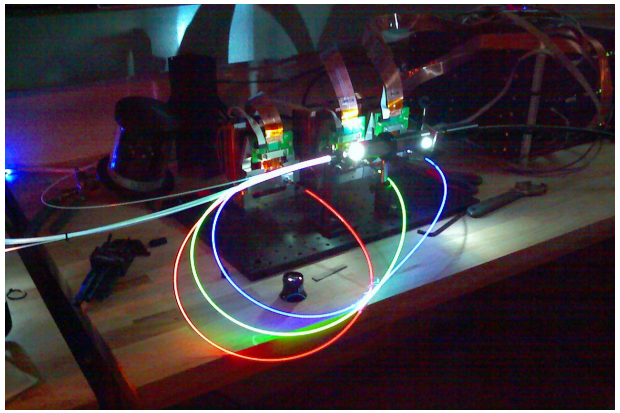
✓ Identified benefits and possible applications for newer lighting technologies.
- Organic Light Emitting Diode (OLED).
- Laser Excited Phosphor (LEP).

✓ Estimated cost and ROI of advanced topside lighting system.
- To be included in final report.

MIL-STD-x743 LIGHTING TECHNOLOGIES



Remote Source Lighting System Schematic



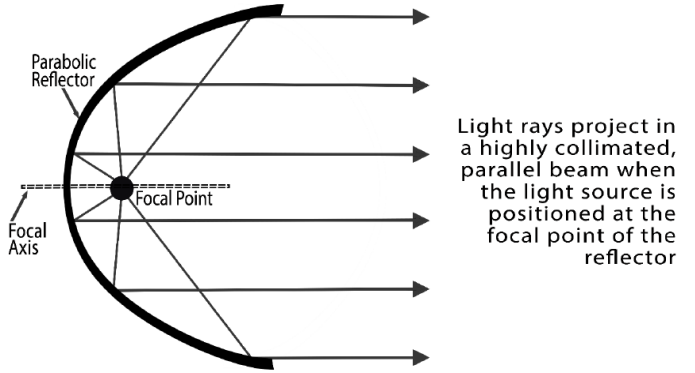
Red-Green-Blue Laser Diodes for White Emission

Modular LED Luminaire

Photo Courtesy of Signal Mate

Fully Encapsulated LED Luminaire

Photo Courtesy of Lopolight



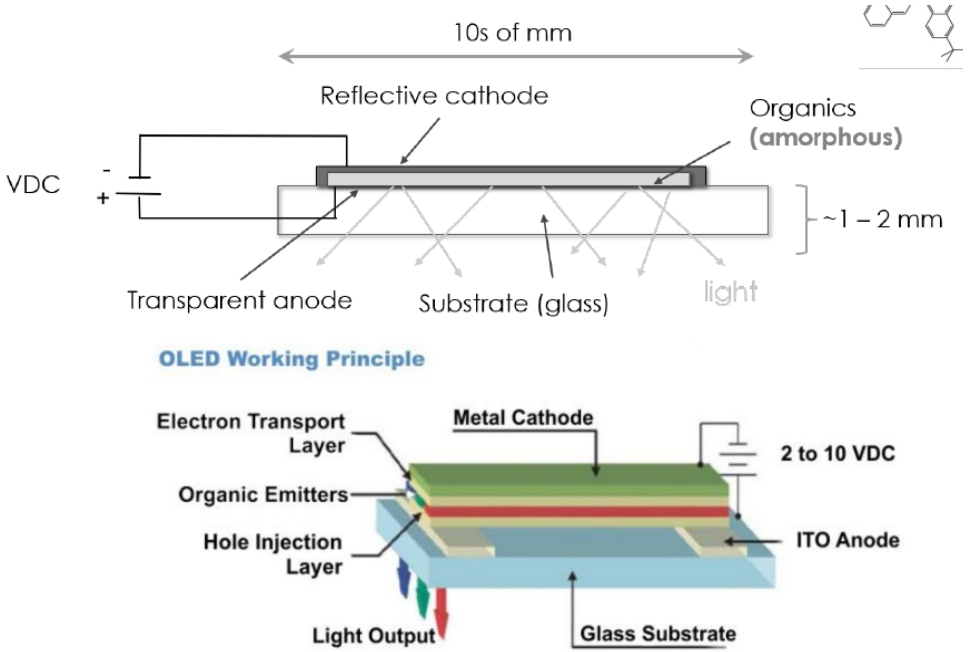
2500 W Xenon Searchlight and Reflector

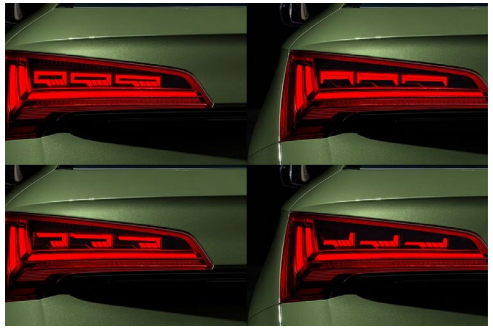
Photo Courtesy of Carlisle & Finch

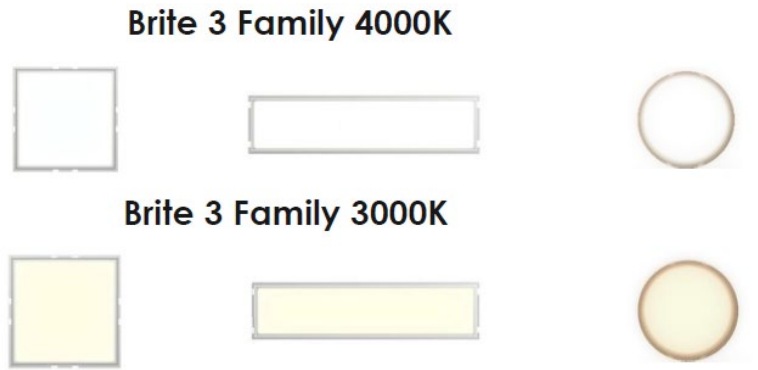
NEWER LIGHTING TECHNOLOGIES - OLED

Organic Light Emitting Diodes

- Exceptionally thin (~ 2 mm), no heatsink, no phosphor covers or diffusors required.
- Emission from entire surface area. Can be surface mounted.
- full spectrum illumination resulting in artificial light that resembles daylight.
- -40°C to 85°C operation, 105°C storage.
- ~ 80 lm/W, 100K hours.
- Used in high vibration environments: automotive and aircrafts.



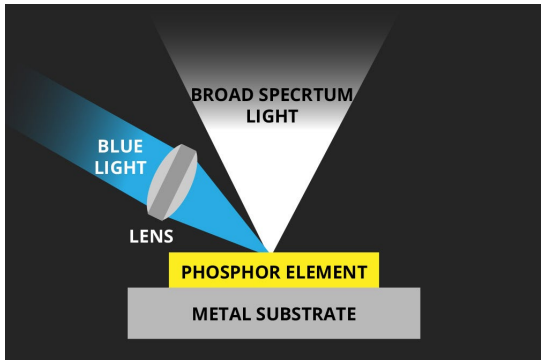


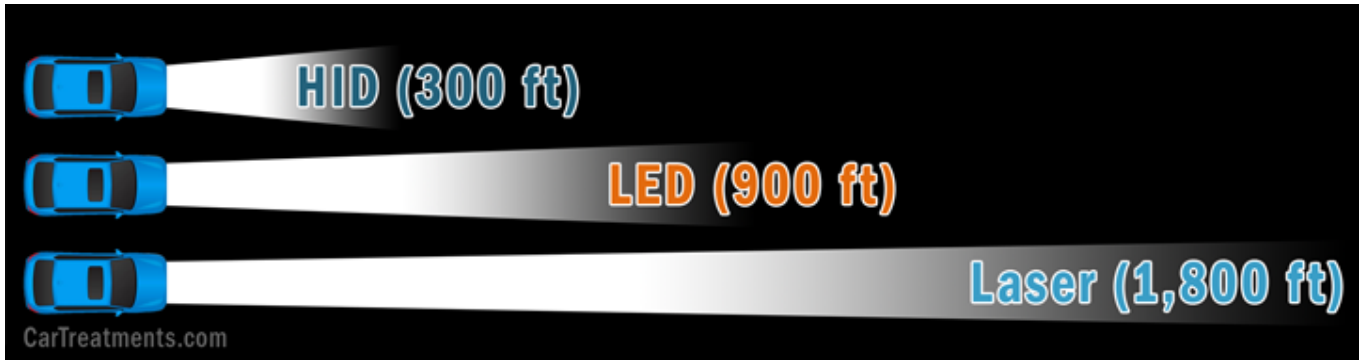


NEWER LIGHTING TECHNOLOGIES - LEP

Laser Excited Phosphor

- High Luminance - Over 1000 Mcd/m² (~100 X standard LEDs).
- Beam angles of 2 degrees or lower without the need for bulky optics.
- Compact lamp sources.
- ~ 10,000 hours life.
- Used for high intensity flashlights and automobile headlights.





Optical Properties		
	CIE x	0.4084
	CIE y	0.3351
	Color Rendering Index (CRI)	93
	Color Temperature (K)	2890

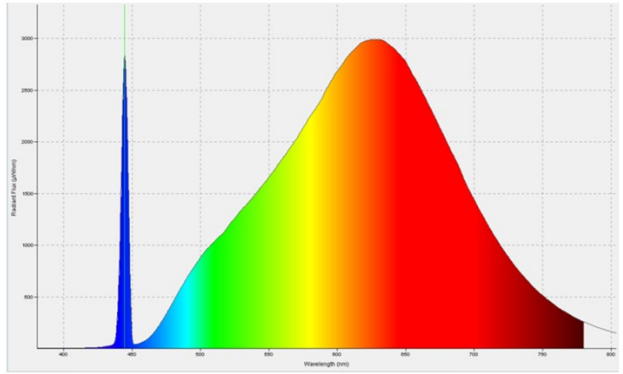


Image courtesy of phosphor.com

MIL-STD-x743 TUTORIALS TOPICS

TOPIC ADDRESSED	DESCRIPTION
SOLID STATE LIGHT SOURCES	SSL technologies' description, operation, and safety.
Light Emitting Diodes	Description of the LED technology and benefits.
Considerations when Replacing Incandescent with LED Lights	Differences between Solid State Lighting (SSL) sources and incandescent (legacy).
Laser Diodes	Description of laser diodes including RGB and LEP.
ELECTROMAGNETIC INTERFERENCE MITIGATION	Effects of EMI / RFI as related to SSL.
LED LUMINAIRES	Requirements and configuration of LED luminaires.
REMOTE SOURCE LIGHTING SYSTEM	RSL components and implementation.
ADVANCED TOPSIDE LIGHTING SYSTEM CONFIGURATION	Considerations in the selection of lighting devices.
SEARCHLIGHTS	Overview of the searchlights' technology.
SEARCHLIGHTS - SPECIFICATIONS	Functional requirements of searchlights.
LIGHT INTENSITY CALCULATIONS	Calculations methodology.

NOTES:

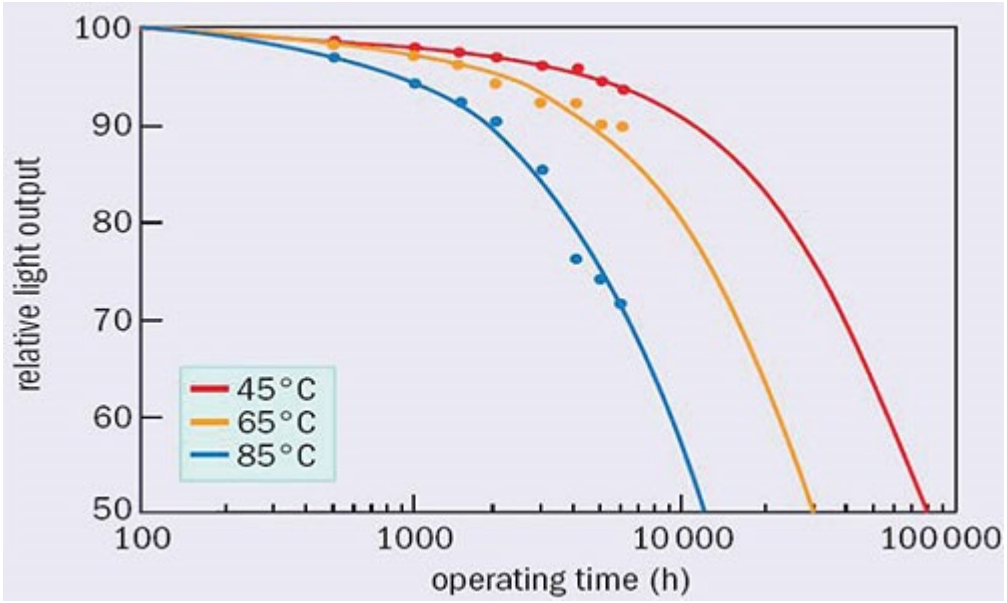
1. Additional tutorials to be provided to NAVSEA after project completion.
2. Special thanks to:
   i. Carlisle & Finch for searchlights overview and requirements.
   ii. Signal Mate for considerations when implementing LED Nav lights.
   iii. Penn State U ARL for EMI considerations.

MIL-STD-x743 LEGACY TO SSL TRANSITION

COLREGS COMPLIANCE

CONSIDERATIONS

- Incandescent:
  - 100% intensity to 0 (failure).
  - Control panel detects open circuit.
- SSL Devices:
  - Slow decay in intensity to end of life.
  - Affected by drive current / environment / temperature.
  - May fall below COLREGS requirements before stated hours.
    - No open circuit to be detected by Control panel.



Solid State Devices – Operating Life vs. Temperature

SOLUTION

- Monitor intensity.
- Trigger "Open" circuit if below COLREGS.

MIL-STD-x743 REQUIREMENTS FOR LIGHTING GROUPS

EXTERIOR LIGHTING

REQUIREMENT	MIL / Reference	Nav/ Signaling	Searchlights	RAS/ FAS	Waterline Security
COLREGS Compliance	USCG 72 COLREGS	X			
EMI/RFI	MIL-STD-461E	XX	XX	XX	
Low RCS		X		X	
Intensity Decay Monitor	IMO MSC 253 (83) Section 4.3	X			
0 / 50% Dim	USCG 72 COLREGS / DOD-HDBK-289	X			
0-100 Full Dim	Digital Addressable Lighting Interface (DALI)		X	X	
Morse Code			X		
Full Spectrum Emission			X	X	X
Salt Spray Resistance	ASTM B 117	X	X	X	X
NVIS Compatibility	MIL-STD-3009	X		X	
Corrosion	NAVSEA INSTRUCTION 9630. IA	X	X	X	X
Vibration	MIL-STD-167-1	X	X	X	
Shock	MIL-STD-810	X	X	X	
EMP / HEMP	MIL-STD-188-125-2				
De-Icing		X	X	X	

INTERIOR LIGHTING

REQUIREMENT	MIL / Reference	Nav Bridge	CIC
EMI/RFI	MIL-STD-461E	X	X
0-100 Full Dim	Digital Addressable Lighting Interface (DALI)	X	X
Full Spectrum Emission		X	X
Vibration	MIL-STD-167-1	X	X
Shock	MIL-STD-810	X	X
EMP / HEMP	MIL-STD-188-125-2	X	

NOTE: "XX" indicates that MIL-STD-x743 needs to account for the evolution of other ship's devices that may be affected by or affect the operation of the lights and make provisions for the **possibility of invoking stricter EMI/RFI requirements** on these lighting types.

LIGHTING TECHNOLOGY USE BY APPLICATION

CONDITION	DEVICE TYPE
Luminaire in inaccessible Location (Mast, yardarms, etc.)	RSL
Luminaire and cable in proximity of ISTAR equipment.	RSL
Luminaire in relatively accessible location.	LED
Luminaire weight of utmost concern.	RSL
Luminaire embedded in ship's structure.	RSL
Light type used infrequently.	LED
Frequent high mechanical stress on luminaire.	RSL
Narrow output beam required.	Xenon / LEP

LIGHTING GROUP	LIGHTING TYPE	RECOMMENDED LIGHTING TECHNOLOGY
Navigation and Signaling	Anchor Light - Aft	LED
	Anchor Light - Fwd	LED
	Clearance/Obstruction Light	RSL
	Masthead - Aft	RSL
	Masthead - Fwd	RSL
	Mine Sweeping	LED
	Task - Not under command	RSL
	Task - Man Overboard	RSL
	Task - Restricted maneuv.	RSL
	Side Lights	LED
	Towing - Masthead	RSL
	Towing - Stern	LED
	Stern	LED
	Aircraft Warning	RSL
	Stern Light (Blue)	LED
	Wake light	LED
	Blinker	RSL
Searchlights	8 - inch searchlight	XENON /LED/LD/LEP
	12 - inch searchlight	XENON /LD/LEP
Other Exterior Lights	RAS / FAS	LED
	Waterline Security	LED/LEP/RSL
Interior Lights	Navigation Bridge	LED/OLED
	Combat Information Center (CIC)	LED/OLED

MIL-STD-x743 ADDITIONAL CONSIDERATIONS

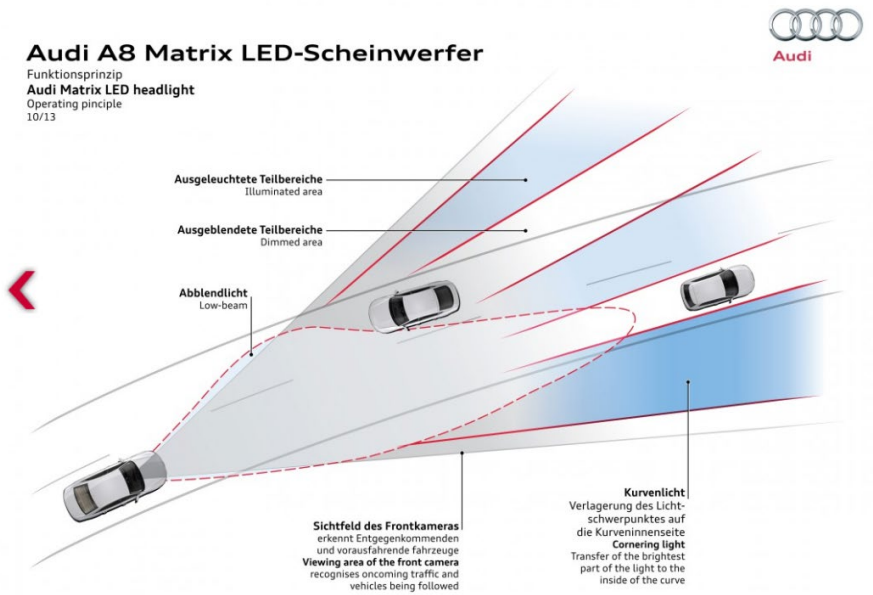
LOCATION / APPLICATION DEPENDENT REQUIREMENTS

- NVIS compatible / friendly / invisible.
- Effects on personnel health.
- Effects on Circadian Rhythm:
  - Promote sleep vs. Maintain alertness

INDUSTRY RESOURCES APPLICABLE TO MIL-STD-x743

- Laser Industry Projection Association (LIPA) activities in areas of **safety and compliance** .
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) studies on effect of LEDs on human health https://www.icnirp.org/en/applications/led/index.html .
- Audi Adaptive Headlights technology https://www.audi-technology-portal.de/en/electrics-electronics/lighting-technology/matrix-led-headlights .
- Audi OLED technology https://www.audi-technology-portal.de/en/electrics-electronics/lighting-technology/oled-lighting-technology .

https://rewa.tech/oled-vs-led-impact-on-eye-health-explored/



Matrix LED headlights - Audi Technology Portal

QUESTIONS?

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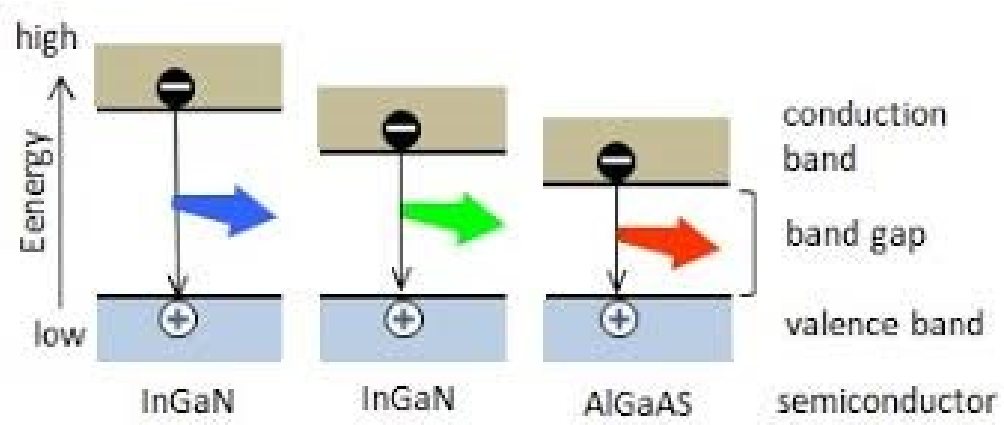
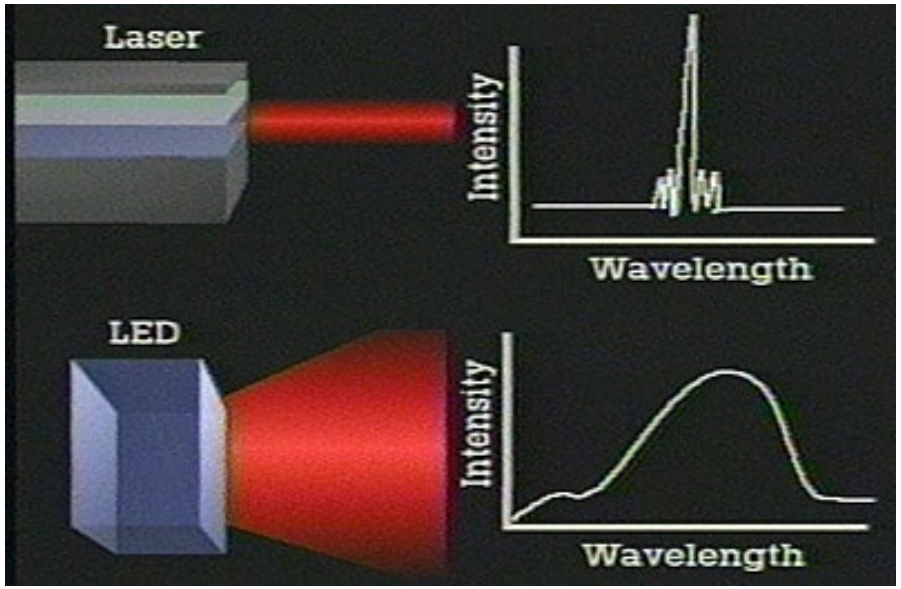
BACKUP SLIDES



LED Chromatic Emission Schematic

(Photo Courtesy of Fiberlabs, inc)



Laser Diode vs. LED Emission