NSRP National Shipbuilding Research Program

ORGANIC LED (OLED), LOW VOLTAGE SHIPYARD LIGHTING TESTING AND DEMONSTRATION – PANEL PROJECT



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NSRP National Shipbuilding Research Program

Organic LED (OLED), Low Voltage Shipyard Lighting Testing and Demonstration

Reduced Production Costs, Order of Magnitude Reduction in Weight/Volume, Increased Crew Health & Safety

Team: LEAD | OLEDWorks, LLC | Acuity Brands | Huntington Ingalls (Pascagoula) | GD/Bath Iron Works

Problem Statement: Reduce Shipbuilding Labor/ Material Costs

Eliminate need for Bonding and Grounding of general-purpose shipboard lighting fixtures during ship construction.

OLED Shipyard Lighting Concept Rendering



Solution/ Approach

- Adapt / ruggedize commercial OLED lighting
 Implement as Low-Voltage DC
- (<28VDC)
 Mounting & Photometrics Demonstration / Measurement
- Shock & Vibe screening
- TOC analysis

AeroLiner3000 prototype with OLED fixtures

- Project Benefits with OLED ;
 Significant Reduction Bonding &
- Grounding Labor & Material
- Reduced Weight & Volume
- Eliminate Electrical Shock Hazard (<28VDC)
- Increased Crew Comfort due to OLED light characteristics vs fluorescent / LED
- Reduced onboard HAZMAT

TBD Project Completion

Project ROI

in 2021

Brite 3 OLED panel by OLEDWorks

Red segmented OLED automotive taillight panels

Fixture with amber

OLED panel by OLEDWorks

OLEDWorks

#1

Upwards of 10 tons in reduced weight associated w/ general purpose shipboard lighting

#2

Significant reduction in shipyard lighting installation labor hours and parts during construction

#3

Increased margin (space & weight) for mission critical systems



Problem Statement

- Reduce shipbuilding costs related to installation of lighting -- eliminate bonding and grounding
 - 2018 Panel Project Feasibility of Low-Voltage DC Shipboard Lighting <u>https://www.nsrp.org/project/low-voltage-shipboard-lighting-feasibility-study/</u>
 - Page 8: OLED lighting is an alternative to LED/solid-state light (SSL) sources that use organic materials as the light source. An OLED source emits light across the entire surface area, producing high quality illumination. The thermals of OLED devices are more easily managed (compared to SSL), allowing new concepts for fixture designs. OLED is a newer technology and the performance is currently lagging that of SSL; however industry is working aggressively to develop this technology. The technology has the potential to greatly reduce weight and increase options for interior lighting systems. Appendix A provides additional information on OLED technology and feasibility for low voltage shipboard applications.
 - Page 10: Given that the intent of this study is to determine feasibility of the low voltage approach, system design and layout would be recommended for follow on activity.

Panel Project SOW - Tasks

TASKS

- Task 1: Develop Fixture & Demonstrate and Mounting Techniques
 - o Task 1.1: Refine requirements for mounting, maintenance and space illumination
 - o Task 1.2: Design options for fixture; light modeling of space
 - o Task 1.3: Fixture fabrication
 - Task 1.4: Installation demonstration in mock or real space
- Task 2: Fixture robustness testing shock and vibration
- Task 3: Demonstrate light distribution including white, amber and red lights
- Task 4: Quantify savings / cost avoidance, Total Cost of Ownership
 - Task 4.1: Installation and maintenance costs
 - Task 4.2: Space and weight savings
- Task 5: Define solutions for improvement
- Task 6: Summary and Recommendations



Panel Project SOW - Partners

- Acuity Brands Luminaire Manufacturing Partner
 - Current supplier to DoD facilities
 - Leading global supplier
- Huntington Ingalls Industries, Pascagoula
 - Shipyard stakeholder
 - Mounting / installation consulting
 - Environmental (Shock)Testing
 - Demonstration
 - Metrics support
- General Dynamics, Bath Iron Works
 - Shipyard stakeholder
 - Mounting / installation consulting
 - Demonstration in mock space explore leverage opps
 - Metrics support
- NAVSEA / NSWC PD (NAVSSES)
 - NAVSEA Technical Authority











Project Schedule Status

5													. <u>I</u>			
TASKS/DELIVERABLES	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-2	1 Apr-21	May-21	Jun-21
Task Order Award																
Project Kick-off Meeting																
Task 1 - Develop Fixture & Demo Mounting Techniques																
Task 1.1 - Define Requirements for Mounting, Maintenance and Space Illumination																
Task 1.2 - Design Options for Fixture; Light Modeling of Space																
Deliverable 1 - Requirements Defined				4	4	4										
Deliverable 2 - Fixture Design Approved				4	4	4	L									
Deliverable 3 - Quarterly Status Report					<u> </u>											
Task 1.3 - Fixture Fabrication																
Task 1.4 - Fixture Installation																
Deliverable 4 - Fixtured Fabricated / Delivered												.:		4		
Deliverable 5 - Quarterly Status Report							4	Δ								
Deliverable 6 - Installation										<u> </u>				Δ		
Task 2 Fixture Robustness Testing																
Deliverable 7 - Shock Testing Report																Δ
6683470 · Demo Light Distribution (Whte, Amber, Red)																
1 ble 8 - Photometrics & Modeling Report										7						Δ
Task 4 - Metrics																
Task 4.1 - Installation & Maintenance Costs																
Task 4.2 - Space & Weight																
Deliverable 9 - Quarterly Status Report										. 4	Δ.		. 1			
Deliverable 10 - TOC Report											Δ					Δ
Task 5 - Solutions for Improvement																•
Deliverable 11 - Perfomance Analysis / Recommendations																
Task 6 - Summary / Recommendations																Λ
Deliverable 12 - Final Report	14- 20	4	14- 20	1	1.1.20	A	Car 20	0.4.20	No. 20	Dec 20	1000 24	5-k 24		1 4	14- 24	
	Mar-20	Apr-20	Way-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21

Panel Project Status – Task 1.1 – Requirements

Dolivorabla	#1 Cubm	vittad			
Deliverable	<u># I SUDII</u>	IIIIeu		Space	Average initial footcandles
	Antenna States			General lighting (30 inches	above deck)
	NSRP		Passage	ways	7
OLED Works			Living s	spaces, except as follows:	14
Naturally Illuminating	There Internet			Staterooms	7
				Berthing areas	7
T			Sanitary	/ spaces, except as follows:	14
				Shower area	3
Organic LED Low-Vo	Itage Shipboard		Food se	rvice and messing spaces	28
Lighting – Testing ar	nd Demonstration		Refrige	rated and dry provision storerooms	14
Task 1 Deliverable – Rec	quirements –		Lounge	, recreation, and welfare spaces	14
Revision 1			Library	multimedia resource center (LMRC)	28
			Persona	l service spaces, except as follows:	14
Submitted by OLEDWorks LLC, on	behalf of Project Team Members			Ship store	28
				Post office	28
SecurityBrands.	Bath Iron Works			Vending machine area	7
31 Au	gust 2020			Detail lighting	, ,
	5001 D T L O L 2000 257		Bulletin	boards	14
NSKP Panel Project – Task Orde	er 001 – Base Task Order 2020-357		Desk an	id writing tables	42
			Food pr	reparation counter, range tops,	42
<u>Category B Data – Go</u>		Table 1 - Requirements References	off-load serving	ling end of dishwashers, and food lines	
Distribution authorized to project	Reference	Applicability/ Requirement	Barber	shop chair	42
report is cons	Mil-DTL 16377J	Comprehensive, overarching specification gui	Laundry	y press area	28
	Mil-HDBK 289	Comprehensive guide for shipboard lighting			
		installation			
	NAVSEA Tech Pub	Ft-Candles – Habitability – Cites OLED as poten	itial		

for future lighting technology

Class 2 lighting fixtures

Mil-DTL-901E

Mil-DTL-167-1

Mil-DTL-24643

Mil-DTL-108-E

High Impact Shock Test – Provides high-impact

Mechanical Vibrations of Shipboard Equipment

Enclosures for Electrical / Electronics Equipment

Cabling for Low Smoke, Halogen Free

testing requirements and procedures for Type III,

Table 1-2. Compartment Illumination Levels.

Panel Project Status – Task 1.2 – Design



Panel Project Status – Task 1.3 – Fabrication

- Deliverable #3 In Process Delayed to Supplier Issue
- Delivery date to Hii & BIW pushed right to 30 March-

NSRP PANEL PROJECT -	MATERIALS								
PHASE									
Initial - JAN	Linear 1X3 unit	F.F.F.	1	3	0	0	3	ABL	Testing, Form Fit Function
Testing -JAN	Linear 1X3 unit	Photometry	1	3	0	0	3	ABL	Testing
Initial - JAN	Linear 1X3 unit	Sample	2	6	0	0	6	OW / ABL	At least (1) in tact to ABL and OW for continued evaluation
Deliverable 8-FEB	Linear 1X3 unit	Mockup	18	54	0	0	54	Hii	(X2) 1X3 Fixture per (9) mounting locations, simulates 2x3 OLED Luminaire
Deliverable 8-FEB	Linear 1X3 unit	Mockup	20	60	0	0	60	BIW	(X2) 1X3 Fixture per (10) mounting locations, simulates 2x3 OLED Luminaire
Deliverable 7-FEB	Linear 1X3 unit	Shock	2	6	0	0	6	Hii	(2) required
Deliverable 7-FEB	Linear 1X3 unit	Vibe	2	6	0	0	6	BIW	(2) required
Deliverable 12-MAR	Preview WHT + RED	Photometry	1	2	1	0	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
Deliverable 12-MAR	Preview WHT + AMB	Photometry	1	2	1	0	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
Deliverable 12-MAR	Preview AMB only	Photometry	1	0	3	0	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
Deliverable 12-MAR	Preview RED only	Photometry	1	0	0	3	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
LINEAR 1x3 HOUSINGS	REQUIRED		50					ABL	
40K OLED PANELS REQUIRED				142				OW	Brite 3, Rect, 4000K
AMBER OLED PANELS F	REQUIRED				5			OW	
RED OLED PANELS REQ	UIRED					3		OW	
OLED 24VDC DRIVERS F	REQUIRED						138	3 OW	OWUDM
24VDC POWER SUPPLIE	ES							OW	Shipyards to provide 24VDC to luminaires

 Task 1.3 Represented Most Significant Schedule Risk

 ---Have Realized that Risk

Panel Project Status – Task 1.4 – Installation

- Deliverable #6 Pending Task 1.3 Mid-April Possible May more likely
- Demo / install sites ID'd at Hii and BIW
- BIW demo rig designed (conducted site 10/5)

PHASE	LUMINAIRE	ТАЅК	LUMINARE QTY / TASK	40K OLED QTY	AMB OLED QTY	RED OLED QTY	DRV QTY	OWNER	COMMENT
Initial - JAN	Linear 1X3 unit	F.F.F.	1	3	0	0	3	ABL	Testing, Form Fit Function
Testing -JAN	Linear 1X3 unit	Photometry	1	3	0	0	3	ABL	Testing
Initial - JAN	Linear 1X3 unit	Sample	2	6	0	0	6	OW / ABL	At least (1) in tact to ABL and OW for continued evaluation
Deliverable 8-FEB	Linear 1X3 unit	Mockup	18	54	0	0	54	Hii	(X2) 1X3 Fixture per (9) mounting locations, simulates 2x3 OLED Luminaire
Deliverable 8-FEB	Linear 1X3 unit	Mockup	20	60	0	0	60	BIW	(X2) 1X3 Fixture per (10) mounting locations, simulates 2x3 OLED Luminaire
Deliverable 7-FEB	Linear 1X3 unit	Shock	2	6	0	0	6	Hii	(2) required
Deliverable 7-FEB	Linear 1X3 unit	Vibe	2	6	0	0	6	BIW	(2) required
Deliverable 12-MAR	Preview WHT + RED	Photometry	1	2	1	0	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
Deliverable 12-MAR	Preview WHT + AMB	Photometry	1	2	1	0	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
Deliverable 12-MAR	Preview AMB only	Photometry	1	0	3	0	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
Deliverable 12-MAR	Preview RED only	Photometry	1	0	0	3	benchtop	ABL	Preview Possibilities by END OF PROJECT, Remote Drivers
LINEAR 1x3 HOUSINGS	REQUIRED		50					ABL	
40K OLED PANELS REQU	JIRED			142				OW	Brite 3, Rect, 4000K
AMBER OLED PANELS R	AMBER OLED PANELS REQUIRED				5			OW	
RED OLED PANELS REQU	D OLED PANELS REQUIRED					3		OW	
OLED 24VDC DRIVERS R	EQUIRED						138	OW	OWUDM
24VDC POWER SUPPLIE	S							OW	Shipyards to provide 24VDC to luminaires



BIW Demonstrator



Height of mock equipment will vary from approximately 3 feet to 5 feet off the deck

Panel Project Status – Task 2 – Robustness Testing

- Deliverable #7 Pending Fixture Delivery to Hii
- Shock & Vibe Testing Requirements ID'd (Task 1.1)
 - Mil-DT-901E & Mil-DT-167-1
 - 'Screening' test --- not intended for shipboard certification for preproduction prototypes
- Demo / install sites ID'd at Hii and BIW
- BIW demo rig designed (conducted site 10/5)



Panel Project Status – Task 3 – Demo Light Distribution

- Deliverable #8 Pending Fixture Delivery & Installation to Hii / BIW
- Light Distribution Requirements ID'd in Task 1.1





Notional Shipboard Space – Baseline Fixtures Placement Locations w/ Delivered Ft Candles (Modeled)

Light Distribuiton Modeling Verified in Task 3

Panel Project Status – Task 4 – TOC

- Deliverable #10 Pending Fixture Delivery & Installation to Hii / BIW
 - Install at BIW will include 'Time Trial' baseline T12 vs OLED Fixtures
 - Baseline (T12) numbers and wts from NAVSEA (Illustrated below)
 - Need to ID / agree on, set of Cost Elements and Assumptions

	# of ships in Class	Total # of Fixtures	Total 2-foot Fixtures/Class	Total T12/ship	Total T12/class	Co	ost for T12 Lamp				
Hull							\$45				
DDG-51		2376	1727	3476		\$	155,551.0	00			
DDG-88	39	3009	2360	4780	186420	\$	213,905.0	00			
DDG-90	21	. 2974	2321	4683	98343	\$	209,564.2	25			
DDG-111	5	3014	2376	4818	24090	\$	215,605.5	5 <mark>0</mark>			
CG-52	16	2467	2352	4716	75456	\$	211,041.0	00			
CG-68	6	2604	2525	5206	31236	\$	232,968.5	50			
CVN-77	10	14112	12873	32069	320690	\$	1,435,087.7	75			
LCS-1		973	872	1830	0	Ś	81.892.5	50			
LCS-2/4 (dwg)		835									
LCS2/4 from BOM		936	Fixture	le	vacy T12	1.6	egacy T8	100 300551	W F Harris	FFOL	115360
LCC-19	2	4764	Tixture		5009 112		cgucy 10		vv.i . i i u i i i		LL3300
LSD-41	8	3158	1-lamp stand	ard	8.625	5	8.625	6.750	3.890	7.800	8.070
LSD-49	4	3798	1-lamn flush		10 125	5	10 125	8 250	4 620	10 000	10 070
LPD-17	10	7450			10.123	-	10.125	0.250	1.020	10.000	10.070
LHD-5	9	9379	2-lamp stand	ard	12.000	0	12.000	9.625	5.830	10.400	8.070
			2-lamp flush		13.813	3	13.500	11.438	5.940	12.800	10.000
			3-lamp stand	ard	15.688	8	15.688	12.063	7.660	12.300	8.070
			3-lamp flush		17.825	5	17.875	14.250	8.240	14.900	10.070
			3-lamp CIC								
			standard		19.250	0	19.250	15.625	19.250	19.250	19.250

Using Standard NAVSEA R-TOC Template

21.438

21.438

17.813

21.438

21.438

3-lamp CIC flush

21.438

Summary / Issues

- Have a solid design for OLED-based shipboard lighting fixture
- Fixture fabrication delay 1st run of acrylic panel slightly out of tolerance rework in process
- 90 day NCE request under review
- Deliverable consolidation into Final Report economizing on limited re\$ource\$



Project Contacts

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