

Ingalls Shipbuilding

A Division of Huntington Ingalls Industries

Solid-State Ship Lighting System Evaluation

NSRP Electrical Technologies Panel Project Technical Update

All Panel Meeting Newport News, VA October 6, 2011

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HII- Ingalls**

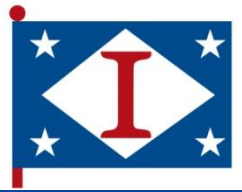
Agenda



- Project Update
 - Brief Review of Project
 - Trade Study Conclusions



Project Overview



Objective:

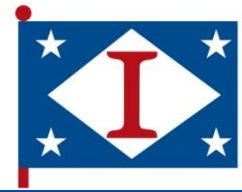
Evaluate the fleet readiness of Solid-State Lighting (SSL) systems and conduct a shipbuilder's trade study to identify cost impact and payback of implementing SSL systems.

Tasks:

- Conduct Market Survey
- Identify System Options
- Conduct Technical Evaluations
- Develop Shipbuilder's Trade Study

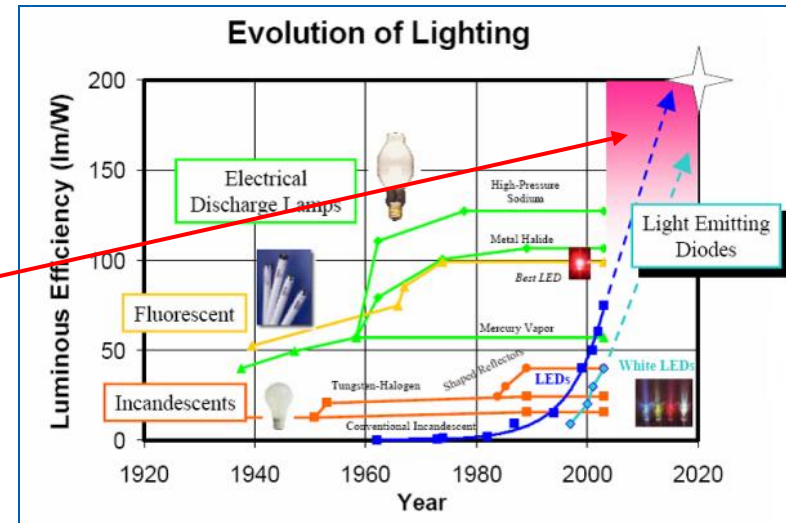


Benefit of LED Systems



Benefits:

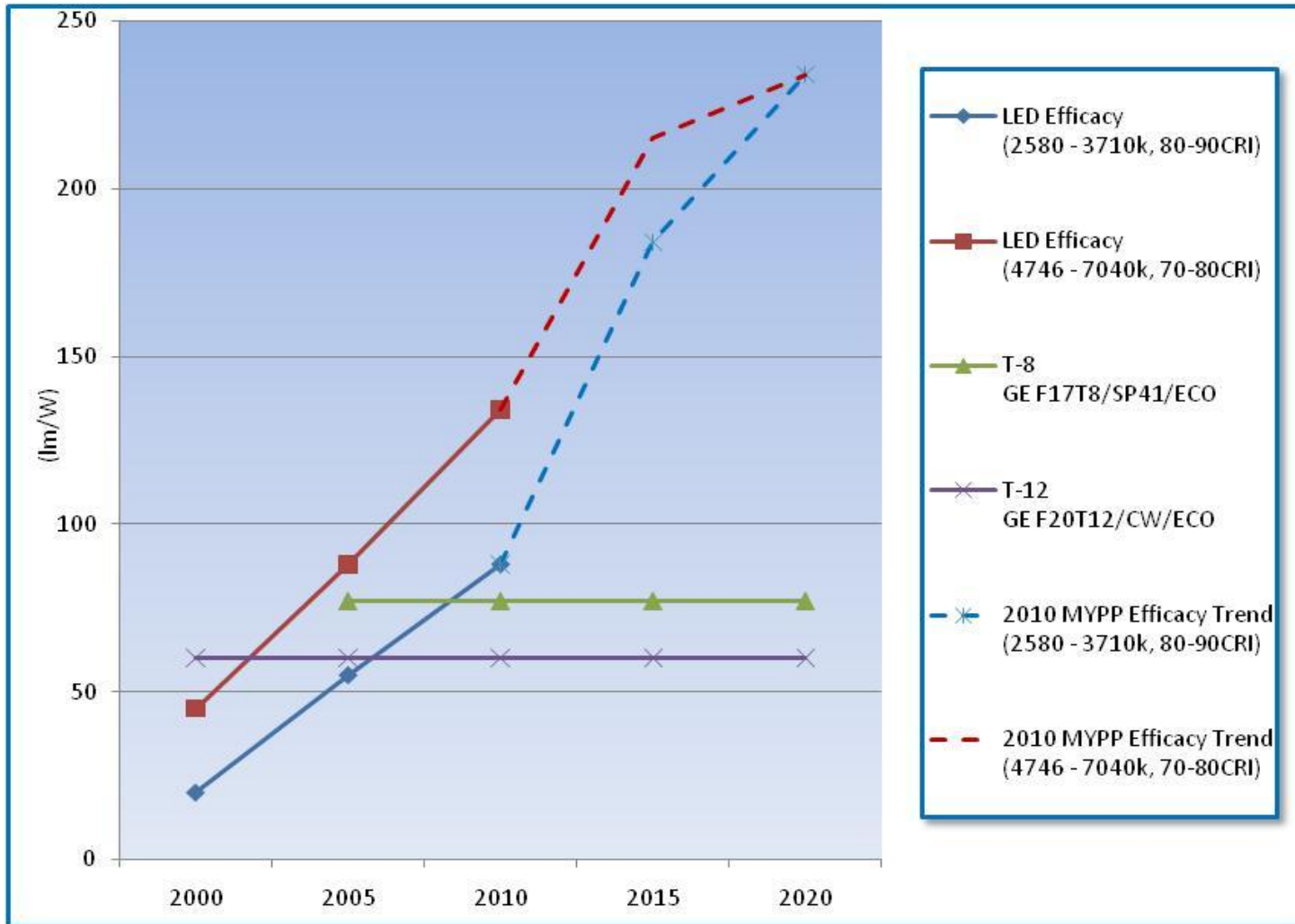
- Long-life light source
 - Greater than 7x compared to legacy sources
- Energy efficient light source
 - Less power for equivalent light output
 - LED efficacy expected to more than double in coming years
 - USDOE 2010 MYPP defines new, higher efficacy predictions for SSL systems
- Supports Navy's **Green Fleet Initiative**
- Support life-cycle cost reduction efforts
 - Reduce maintenance
 - Reduce storage
 - Reduce disposal
- Better suited for rugged environments
 - Shock & vibration resistant
- Reduced weight
- Greater battery run-time



USDOE 2010 MYPP		
	LED Efficacy (2580 - 3710k, 80-90CRI)	LED Efficacy (4746 - 7040k, 70-80CRI)
	(lm/W)	(lm/W)
2010	88	134
2012	128	173
2015	184	215
2020	234	234



Comparison of Sources



- T-12 Fluorescent
 - Most common source used in Navy fixtures
- T-8 Fluorescent
 - Recently approved
 - CVN 78



Shipbuilding Interest in SSL



- SSL provides TOC savings
 - Maintenance
 - Energy Efficiency
 - HAZMAT Disposal
 - Storage
- USCG implementation of SSL on Response Boat (RBM) Program
- Navy
 - SECNAV Ray Mabus
 - 5 Energy Targets
 - Great Green Fleet by 2016

There are > ~1.2M
2' Linear Fluorescent
bulbs installed on
USN INSERV Ships



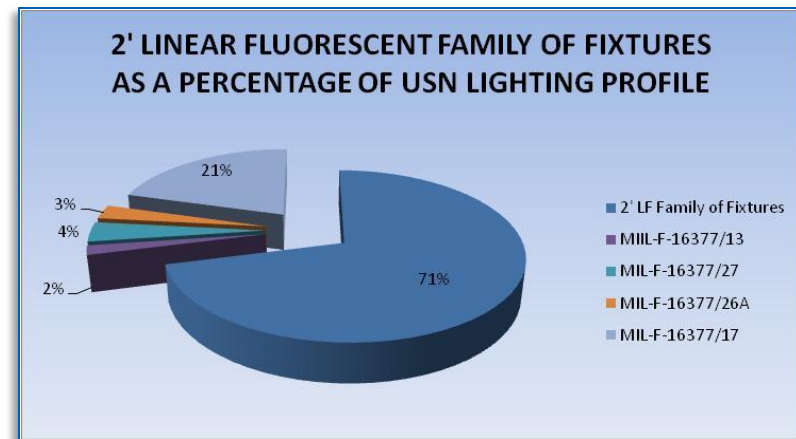
USN Fixtures & Options



Specification	NAVY SYM #	Description
MIL-F-16377/8	331.1	Single tube 2' linear fluorescent light fixture
MIL-F-16377/11	77.4	Two tube 2' linear fluorescent light fixture
MIL-F-16377/12	333.1	Three tube 2' linear fluorescent light fixture

Common Options:

- EM – Battery back up power supply
- R – Red mode of operation





- Identified and contacted suppliers for both military grade and commercial lighting products
- Two system options were identified for laboratory evaluation in the project:
 - **SSL Fixtures**
 - Form, Fit, Function replacements
 - Developed for Navy ship applications
 - Suppliers: 3M, Energy Focus, I2Systems, LC Doane, LightPod
 - **SSL Bulb Replacement**
 - Currently used in commercial market
 - Not widely accepted, due to high efficacy of fluorescent bulbs used commercially
 - Navy ships primarily use F20T12/CW bulbs
 - T-8 bulbs have recently been approved for Navy ships
 - CVN 78
 - LHD
 - Suppliers: Elumenus and others commercially

System Options



- **SSL Fixture**

- Form, Fit, Function replacements
- Identical installation (mounting & electrical) as legacy fluorescent fixtures
- Designed to meet MIL-qualifications



I2S SYM 77.4 REM SSL

- **Bulb Replacement**

- Currently used in commercial market
- Size options available
- Direct replacement for T-8 or T-12 fluorescent bulbs
 - Disconnect and remove starter & ballast



2' LED Bulb - Elumenus



Shock Evaluation



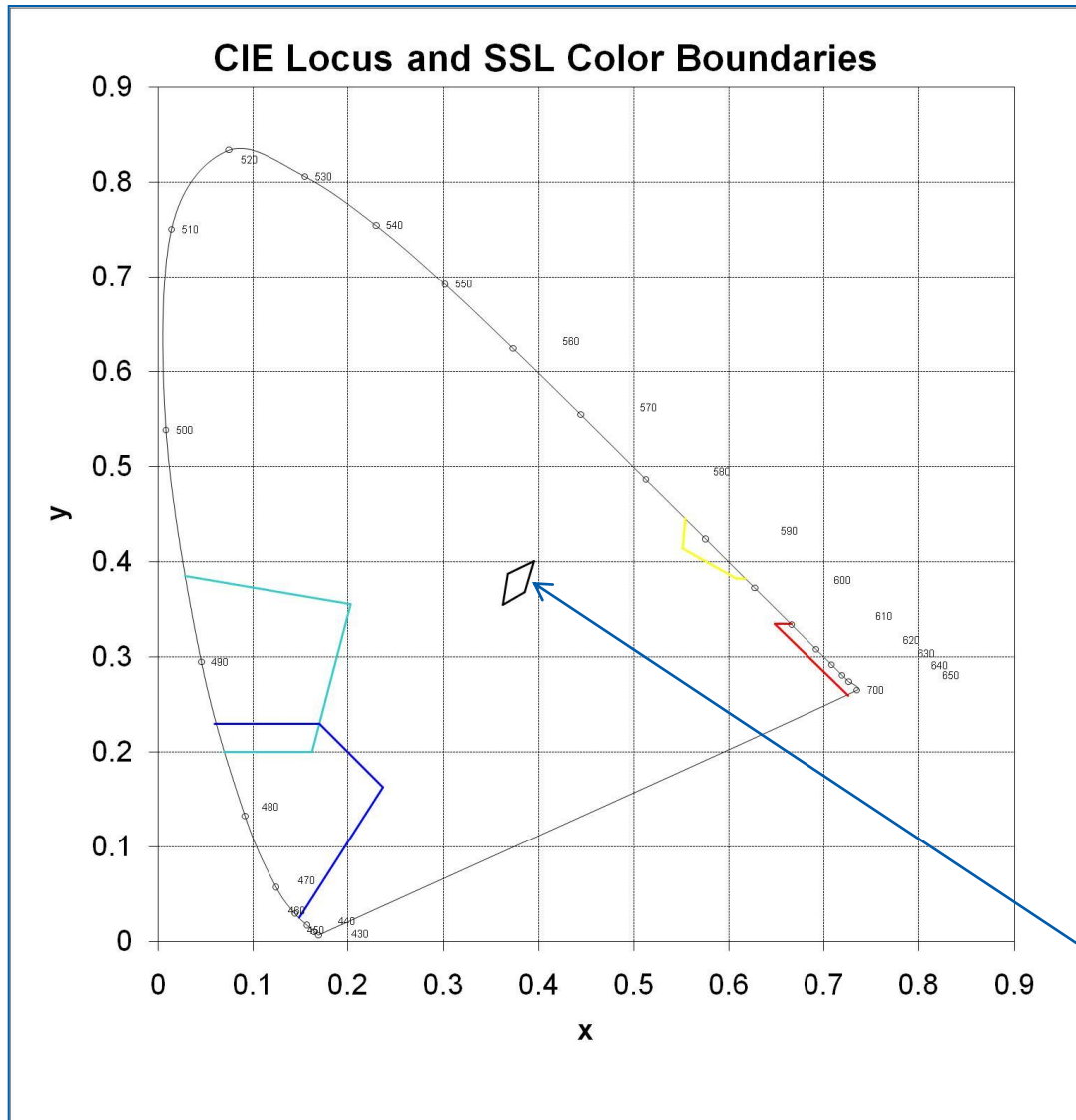
- Fixtures were evaluated for shock compliance per MIL-STD-901
- Certified lightweight shock machine – NGSB Avondale Operations
- 9 Shock Impacts
 - 3 planes
 - 3 impacts per plane
- Fixture must be operable before, during, and after testing
 - No loosening of parts
 - Fully functional



Shock Test Set-Up



Chromaticity Evaluation



Luminaire Output Evaluation

3.9.2.1 **White light.** Chromaticity shall be within the tolerance quadrangle show in Table 1.

Table 1.		
	x	y
Center point 4100K	0.3767	0.3763
Tolerance quadrangle	0.3679	0.3873
	0.3953	0.4009
	0.3853	0.3686
	0.3622	0.3546

MIL-DTL-16377
SSL Supplement
requirement for
white



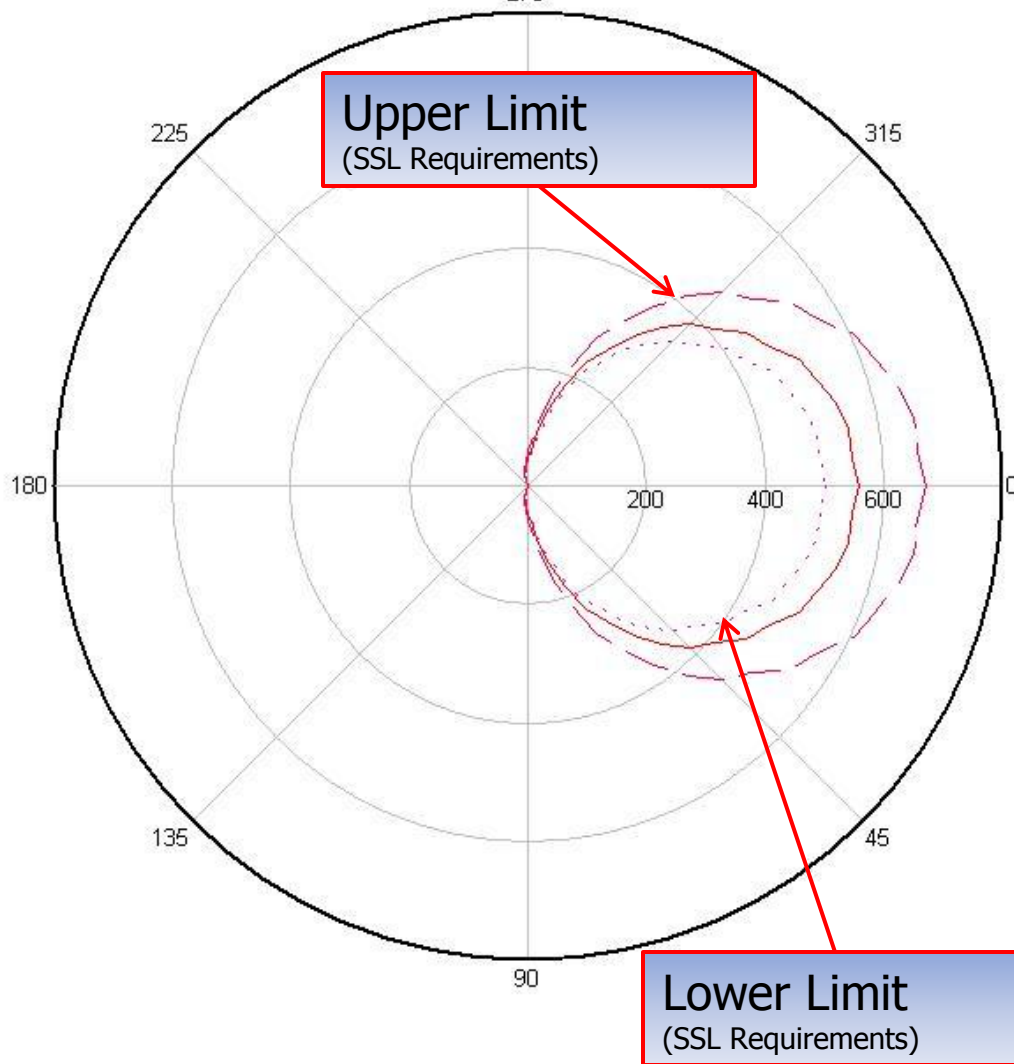
Photometric Distribution: SSL Requirements



SYM 77.4 Distribution Requirements (MIL-DTL-16377-SSL).xls

0-180 Test Data

270



- ✓ Fixture mounted in operational configuration
- ✓ Measurements taken every 5° increment
- ✓ Measurements taken in 0° plane and 90° plane
- ✓ Upper Limit = 20% above curve
- ✓ Lower Limit = 10% below curve
- ✓ LED systems are more directional compared to fluorescent systems
- ✓ Requirements more difficult to meeting in upper angles

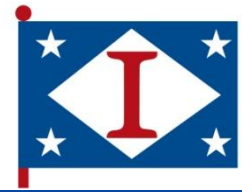


Testing Summary



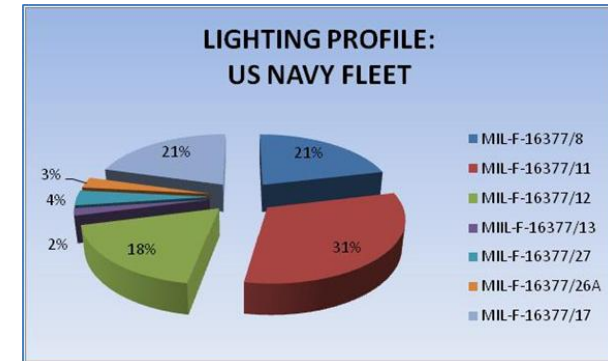
- Three LED options were evaluated
- The COTS LED bulb option is the most energy efficient source evaluated, but did not pass shock, chromaticity, and distribution requirements
 - Design modifications are needed for compliance to Navy standards
- The LED fixture passed all compliance evaluations
- All three LED options are more energy efficient compared to the baseline option



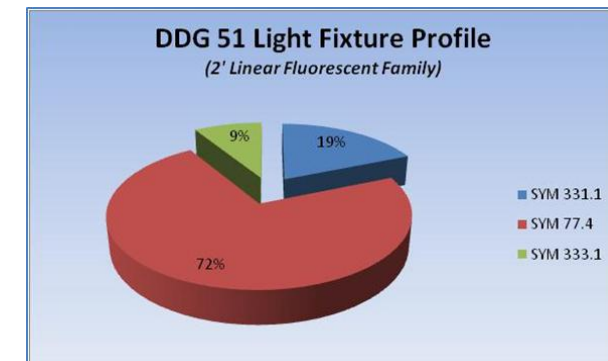


Trade Study Evaluation

- A Shipbuilder's Trade Study was conducted to evaluate **Cost, Schedule, Performance** and **Risk** of SSL system options
- The DDG 51 Class ship was used as a baseline for comparison
- Fluorescent SYM 77.4 fixture was used as baseline for comparison
 - Most common fixture throughout USN
 - Most common fixture on 51 Class
- Trade Study Criteria established with collaboration from NSRP, US Navy, US Coast Yard, shipyards, and industry partners
- A new option of a military hardened LED bulb was added to the study
- A business case analysis was conducted to determine Total Ownership Cost impact and Break-Even Point of system options included in this study



Lighting Profile of US Navy Fleet



DDG 51 Light Fixture Profile



Trade Study Criteria



- 29 individual Criterion were selected by the ETP for inclusion in the study
- Criteria were grouped into four Major Categories
- Major Category weighting was selected based on feedback from ETP
 - Performance was ranked highest

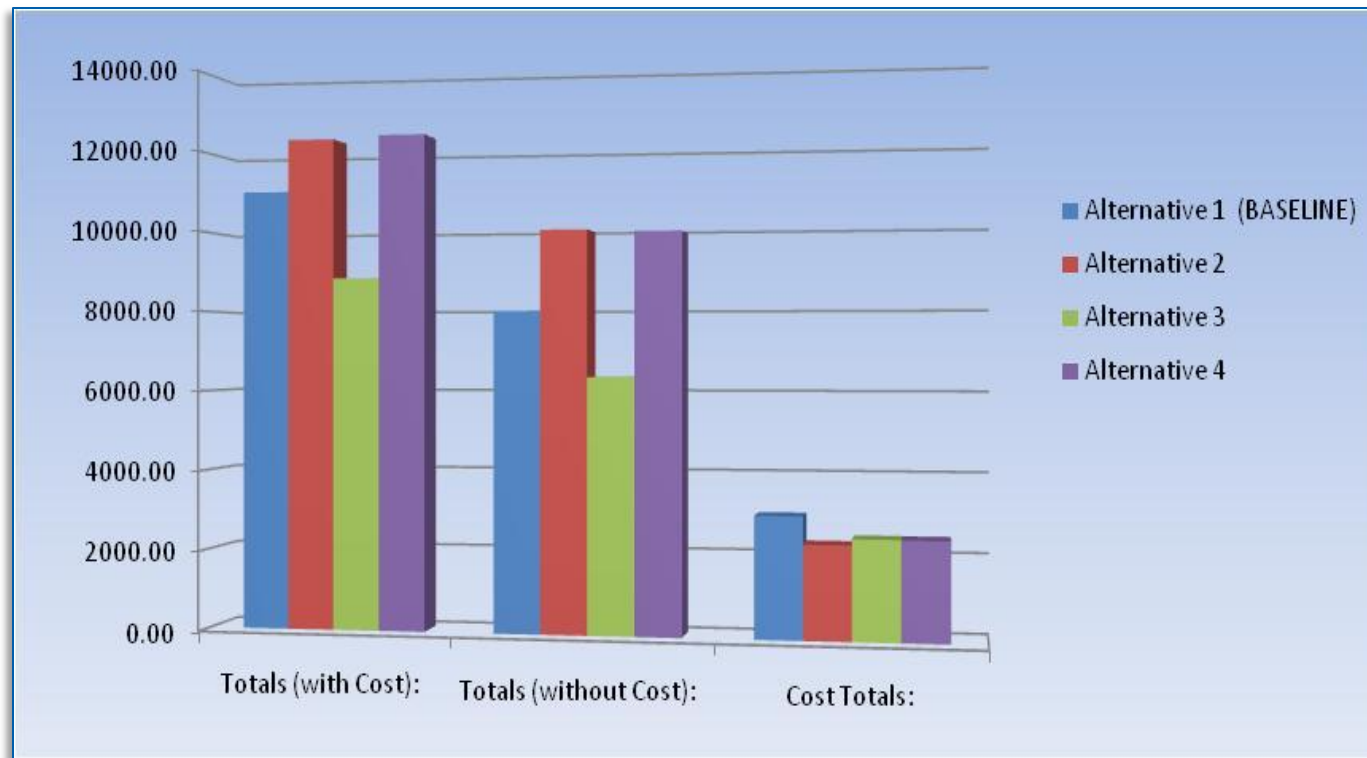
MAJOR CATEGORY	WEIGHT
COST	7
SCHEDULE	2
PERFORMANCE	10
RISK	3



Results & Trends



- The military-hardened LED bulb option scored highest in the trade study analysis
- The military-hardened LED fixture option score was only 0.6% from the military-hardened LED bulb option



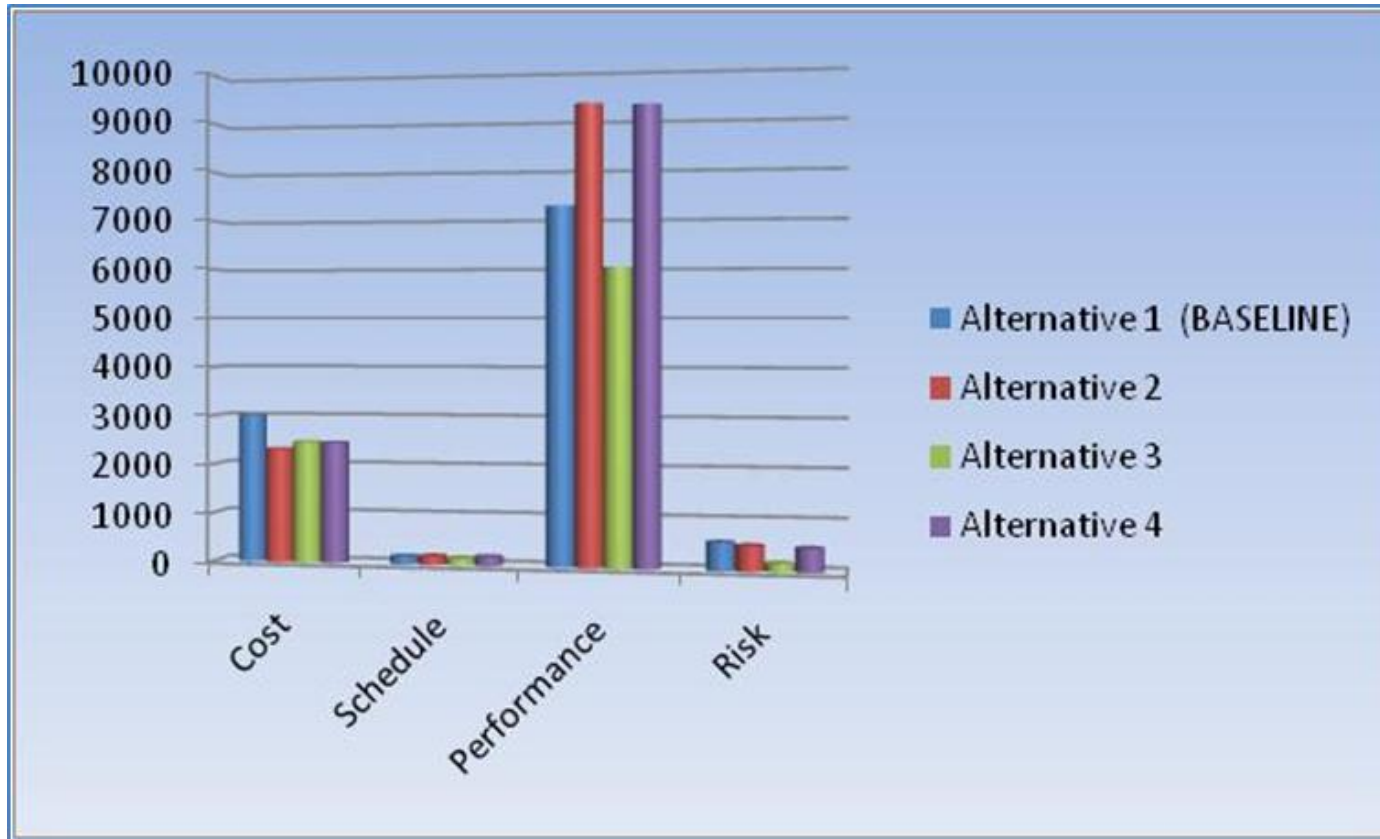
Trade Study Scoring Analysis



Results & Trends (Continued)



- The COTS LED Bulb option was impacted by military performance requirements
- SSL systems are currently being transitioned to the Navy Fleet



Major Category Scoring Totals



Business Case Analysis



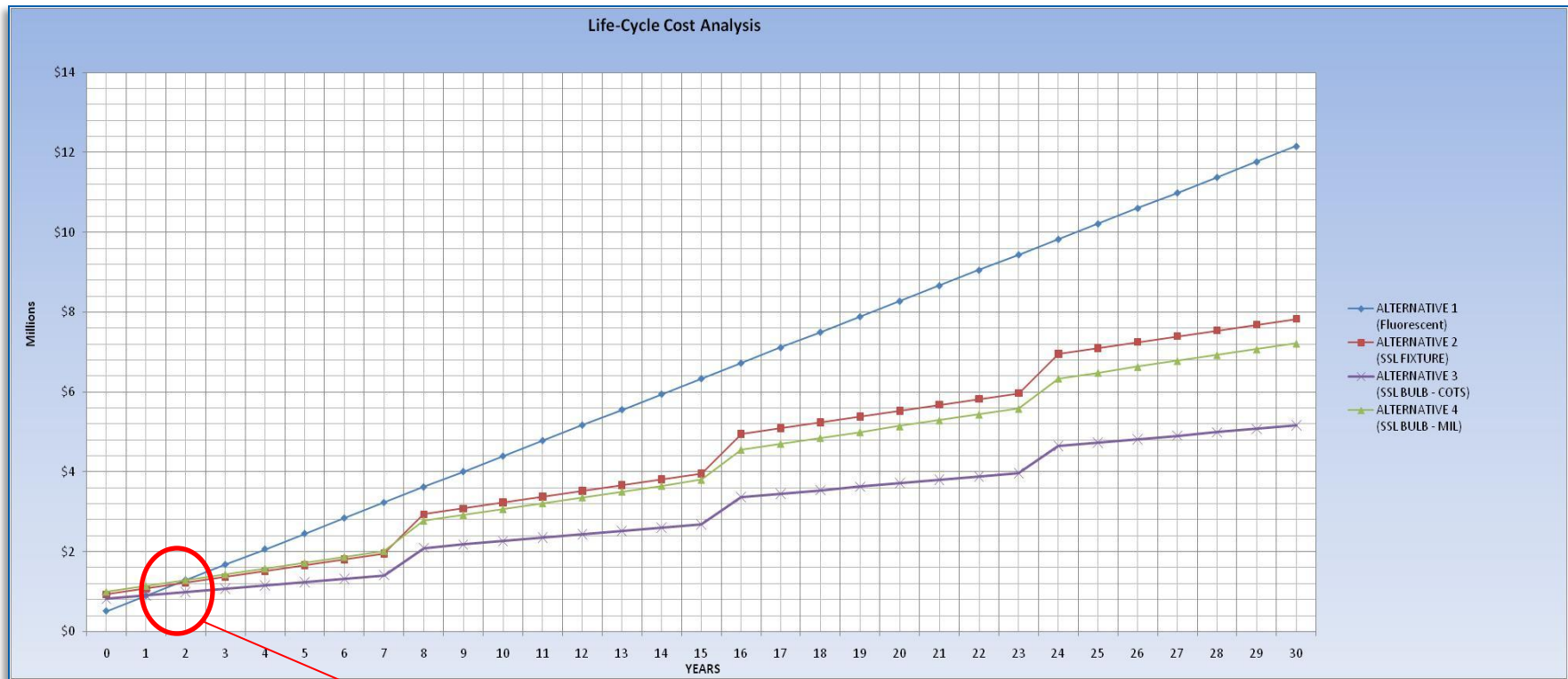
- A Life-Cycle Cost Analysis was conducted on four system options
 - Option 1: Baseline
 - Option 2: MIL SSL Fixture
 - Option 3: COTS LED Bulb
 - Option 4: MIL LED Bulb
- The following were included:
 - **SCN Budget Items**
 - ✓ Light Fixtures
 - ✓ Installation Labor
 - **O&MN Budget Items**
 - ✓ Maintenance Labor
 - ✓ Maintenance Labor
 - ✓ Replacement Lamps
 - ✓ Replacement Starters
 - ✓ Replacement Ballasts
 - ✓ Disposal of Lamps
 - ✓ Fuel



Life-Cycle Cost Analysis



- SSL Options:
 - Higher acquisition cost
 - Lower Total Ownership Cost



~2 year pay-back period



Acknowledgements



Thank You to the following organizations & individuals for their support in this project:

The National Shipbuilding Research Program
NSRP Electrical Technologies Panel
Benjamin Hatch – NAVSEA Code 938
Chuk Eng – NAVSEA 05Z32
Edward Markey – NAVSEA Code 938
Gary Zimak – Newport News Shipbuilding
Gopal Suthar – Ingalls Shipbuilding
Ibrahim Sahawneh – Ingalls Shipbuilding
John Walks – Ingalls Shipbuilding
Justin Montague – Advanced Technologies International
Kim Jovanovich – Omni Technologies, Inc.
Nancy Nunn – Elumenus
Roger Buelow – Energy Focus, Inc.
Ron Wood – Ingalls Shipbuilding
Steve Shapiro – The LC Doane Company
Tom Zampini – Integrated Illumination Systems

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