

# Photon Finish: Tri-color LED Lights

One of three LED tri-color masthead lanterns that Practical Sailor tested, the Orca Green Marine LXTA-12v, showed minimal overlap of the red and green lights, making it easy to distinguish them at all distances up to 2 nautical miles.

## PS tests six high-quality LED bulbs and lanterns for the masthead.

When it comes to navigation lights aboard sailboats, brighter is definitely better. And our latest tests of LED nav lights proved that more light can be made with less energy. In fact, we found that replacing a conventional incandescent bulb with a light-emitting diode (LED) of similar luminosity can result in up to a 90-percent savings in energy consumed over a given period of time.

Practical Sailor's previous evaluations of navigation lights (September 2005 and Jan. 15, 2002) were tests of tri-color masthead lights, sidelights, sternlights, and all-around white lights.

For this review, we narrowed the test field and focused solely on LED tri-color navigation lights (sidelights and a stern light combined in a single fixture) because of the under-sail connotation. They are most often used when the engine is off and the alternator(s) is providing no energy boost to the battery bank. This is when miserly current consumption is most appreciated.

LED lights come in all sizes and shapes, and it has been their monumental improvement in efficiency that has made the technology so appealing to energy-constrained sailors.

In the past, the most popular means of meeting the U.S. Coast Guard's naviga-

tion light requirements for boats under 65 feet (see "Nav Light Requirements," below) was to use an Aqua Signal Series 40 tri-color lamp housing with its long-filament incandescent bulb. Its 25-watt energy appetite not only puts a significant load on the house battery bank, but it requires a heavier-gauge wire be run up the spar in order to avoid an energy-robbing voltage drop. Swapping out the incandescent bulb for an LED drops power consumption significantly and yields just as bright of a light. During a 10-hour night sail, this results in reducing current consumption from about 20 amp-hours down to a scant 2 amp-hours. This savings adds up, and the extra cost of the LED bulb or light will pay for itself in longevity and energy savings.

### LED EVOLUTION

Since the late 1960s, LEDs have followed a trend that amounts to almost a doubling of light output every 36 months. (If Wall Street had done the same, a \$100 investment made in 1969 would today be worth over \$500,000.)

Skipping all the esoteric physics and getting down to basics leaves us with one important concept to grasp: By passing a current through certain semiconductors (materials with only a

few electron holes), the electron flow instigates photon release—or more simply put, light energy is emitted. Modern LEDs comprise an anode (+) and cathode (-) that meet in a tiny cup-like reflector that contains an "n" and a "p" layer of semiconductor material.

In order to achieve white or colored light, phosphor coatings are used. Another significant breakthrough was the prism-like lens and epoxy-sealed cavity that bundles up many of these semiconductors. The resulting "bulb" reflects and refracts the light energy produced,

### NAV LIGHT REQUIREMENTS

Rule 25 of the U.S. Coast Guard's rules state that a sailing vessel shall exhibit sidelights and a sternlight. Boats shorter than 65 feet may have these combined in one fixture (a tri-color masthead light). To comply with accepted standards, the lights must meet the following visibility minimums:

- **Sidelight:** 2 miles for boats over 36 feet; 1 mile for boats under 36 feet
- **Sternlight:** 2 miles
- **Towing light:** 2 miles
- **All-round light:** 2 miles



*Unlike incandescent bulbs, LED lights show little or no loss in brightness as voltage drops below 12 volts.*

out a very wide range of voltage. Contrary to how incandescent lights behave, LEDs show little or no drop in luminosity as voltage plunges below 12 volts DC. In fact, testers ran these lights down to a mega-discharged 6 to 8 volts. The lights remained bright right up until they fluttered off as their load drove the battery voltage below the shut-off point. We monitored power consumption and voltage using a Xantrex Link 10.

Driver circuitry is a key part of LED bulb or lantern design. It controls electrical current as it reaches the semiconductor material, exciting electrons and catalyzing photon release. The more excited the electrons, the more light energy produced.

Unfortunately, a side effect of this process can be spurious radio frequency (RF) energy that can find its way into the receiver side of some electronic equipment, if it's not filtered or attenuated. For example, many masthead VHF antennas have coils mounted very close to where the tri-color light lives, and the relatively weak VHF signals that they pass along to the receiver can be degraded by electronic interference caused by the drivers in some LED lights.

To get a better understanding of how well each manufacturer had addressed the radio frequency interference (RFI) issue in our test products, testers tuned a handheld VHF to the local weather frequency and measured how closely it could be held to a test light before radio frequency interference made the signal unintelligible. One might point out that a tri-color is at the masthead and a handheld VHF is usually 50 feet or more away. However, a 3-Db, masthead-mounted VHF antenna coil often is situated a few inches away from the tri-color light, and RFI is never a signal enhancer. (Signal Mate suggested that in a standard setup, with a VHF antenna's coaxial running inside the mast, *PS* would have found much lower levels of interference from its light, as well as many of the others.)

Some of the lights, Lopolight in particular, were so well filtered that even with the VHF touching the light, there was almost no interference at all. Other test lights completely obliterated the signal, even from more than a foot away.

## Testers Take a Look on the Bright Side

**T**o evaluate the LED tricolors, testers used a series of bench tests and sea trials to gauge their performance. Testers also considered construction quality, design detail, price, and warranty.

To confirm each light's visibility at ranges up to 2 nautical miles, we installed a test setup on *PS* test boat *Wind Shadow*, an Ericson 41. The observers loaded into the dinghy and moved away from the boat, noting the lights' visibility at pre-charted distances of a quarter-mile, a half-mile, 1 mile, and 2 miles. All of the test lights were visible up to 2 miles when the ambient surroundings were pitch black; however, when the background light was elevated, the test lights were swallowed up beyond the 1-mile mark.

Testers used a Gossen Luna Pro incident light meter and a Pentax V spot meter to evaluate each light's luminosity. In addition to measuring brightness, we noted the zone of overlap where the red and green sectors could be easily distinguished.

Testers also noted the off-plane visibility of the lights, an important feature that compensates for vessel heel and roll. Each light was set up on a tripod (on level ground) at a 25-degree angle to mimic heel, and testers measured the luminosity of each at this max tilt point.

LEDs are designed to put out a fixed level of light through-

delivering a color-controlled beam. The plasma-like brilliance of a single-source light creates lens and reflector challenges that each light manufacturer has to deal with. Some makers shape a single beam with lens elements while others use an array of multiple smaller LEDs.

### WHAT WE TESTED

Each of the six LED tri-color masthead lights we tested for this report took a

different approach to implementing the LED technology. The test field included three LED lanterns and three LED bulbs.

From Orca Green Marine (OGM), maker of the top choice among tri-colors in the 2005 *PS* test, we reviewed the latest USCG 2-nautical-mile approved tri-color. The other tested lanterns were self-contained tri-color/anchor light combos from Signal Mate and Lopolight.

Among the bulbs we tested was the Lunasea, a sealed, waterproof LED lamp comprising four green, six red, and six white LEDs. From the LED Shop in Queensland, Australia, we tested the Bay15D white LED bulb with 15 diodes. The supplier recommends its use as a low-consumption (2 watts vs. 25 watts) replacement bulb for the Aqua Signal 40 incandescent. The second sealed bulb we tested was from Dr.

**PS VALUE GUIDE LED TRI-COLOR MASTHEAD LIGHTS**

MAKER	MODEL	PRICE / WARRANTY	CURRENT DRAW	VOLTAGE	LUMINOSITY* (GREEN/RED/WHITE)	BULB TYPE	RFI	
LANTERNS	<b>LOPOLIGHT</b> ★	200-005	\$689 / 5 years	0.3 amps	10 to 32	17g / 17r / 17w	Multi LED	0 inches
	<b>OGM</b>	LXTA-12v	\$340 / 2 years	0.3 amps	8 to 36	16g / 16.3r / 17w	1 / Zone LED	14 inches
	<b>SIGNAL MATE</b> ✓	2-nm Tri	\$359 / 5 years	0.3 amps	12 to 24	16.g / 16.3r / 16.3w	1 / Zone LED	10 inches
BULBS	<b>DR. LED</b> \$	Polar Star 40	\$50 / 1 year	0.1 amps	8 to 30	15.3g / 15.3r / 15.6w	Single LED	4 inches
	<b>LED SHOP</b>	BAY-15D	\$20 / 1 year	0.3 amps	8 to 30	17w	Multi LED	1 inch
	<b>LUNASEA</b> ✓	25NT-24-00	\$71 / Lifetime	0.2 amps	8 to 30	15.3g / 16.3r / 16.3w	Multi LED	2 inches
	<b>AQUA SIGNAL</b> **	25w	\$21 / 1 year	2.1 amps	12 to 14	18w	Incandescent	0 inches

★ Best Choice ✓ Recommended \$ Budget Buy \* Luminosity readings are a linear scale with each whole-number increase representing a doubling of light output. \*\* Aqua Signal incandescent bulb included for comparison purposes

LED, and it is third-party certified to U.S. Coast Guard standards.

**LED LANTERNS**

Boat owners who don't already have a masthead tri-color light, or who plan to replace an old one—hardware and all—would do well to consider an LED lantern.

**ORCA GREEN MARINE**

OGM Inc.'s USCG-approved (third-party tested) tri-color/anchor light (LXTA-12v) squeezes an amazing amount of light from a minimal amount of current (0.3 amps @ 12 volts-DC).

The well-sealed, nicely machined housing and large lenses keep the LEDs in direct line of sight, regardless of heel or the viewer's proximity. Hard, anodized endcaps and Lexan outer lens elements form a tough, water-tight seal. Its internal electronic components are potted in a dielectric sealant, and the lantern comes with a well-sealed pigtail connector.

The manufacturer claims a 50,000-hour full brightness LED life and offers a two-year warranty on the \$340 lantern.

Testers' main concern that arose during testing was that the OGM lantern produced the most RFI of all the gear we tested. Moving the handheld VHF radio to within 14 inches of the light obliterated radio reception.

**Bottom line:** The

OGM lantern is the least expensive in its category, and it proved to be a well-made light. However, its RFI test results held it back.

**LOPOLIGHT**

This expensive, well-designed, and carefully manufactured LED tri-color/anchor light offers a multiple diode approach to illuminating each sector of coverage. The lamp's geometry focuses individual LEDs in narrower beams and uses 36 to cover each colored zone and 44 in the white zone. In addition to adding redundancy with circuitry that allows individual diodes to fail without taking out the entire cluster, the design eliminated the hotspot inherent in tri-color lights that use single-point light sources for each sector.

This light offers a green that's really green (see "Shades of Green," page 14), a dead-ahead aspect with minimal overlap, and a crisp transition to the red zone. The Lopolight also sports a rugged, well-sealed housing that's fully submersible.

Its current consumption is a tiny bit more than the most energy efficient in this group, but the value of having the light continue to work even if one or more diodes give up the ghost

is a big plus.

At \$689, the Lopolight was the most expensive product of all those we tested, but it also had the least RFI. It comes with a five-year warranty.

**Bottom line:** If quality construction and superior performance are your priorities—and cost isn't a concern—the Lopolight will fit the bill. It gets the nod as PS's Best Choice.

**SIGNAL MATE**

Signal Mate products are designed and manufactured by Maryland-based Kimberlite Assemblers Inc. The company sent us a pre-production version of its 2-nautical-mile tri-color lantern for testing.

The searing bright lantern scored high marks for energy efficiency. Its 0.3 amp draw at 12 volts DC compared to some of the more expensive lanterns.

The Signal Mate incorporates a finned alloy base that functions as a heat sink and houses the driver and diodes within a polycarbonate cylindrical tube. Its endcaps and electronics are sealed and bedded in Dow Tough Gel.

Its cylindrical shape makes it well suited for masthead mounting. The light output did not appear hampered at all by the unit's comparably small lenses, even at varying angles of heel.

The design, with a single light source per sector, created a white hotspot, but from 50 to 100 yards away, it was undetectable. Hotspots, a bright white spot that occurs when a single-point white light source illuminates a colored fac-



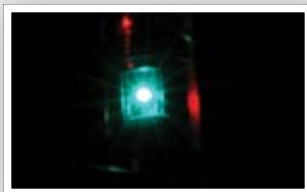
Lopolight 200-005



OGM LXTA-12v



OGM LXTA-12v



Signal Mate (prototype)



Lunasea 25NT-24-00



Lopolight 200-005

## Standards Dictate Tolerance for Color Differences

One thing that stood out to us during testing was the variations of the “greens” that the LED tri-color lights displayed. This left us wondering what the standards that regulate navigation lights had to say about tolerance for differences in color. Does green have to be true green? Or could it be more yellow-green?

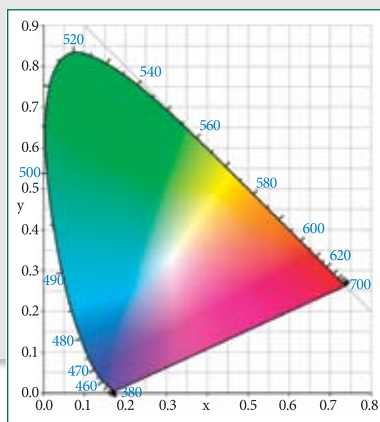
We asked Bob White, president and owner of IMANNA Laboratory Inc., an approved testing facility that evaluates navigation light compliance. He gladly offered to shed some light on the subject.

According to White, the U.S. Coast Guard, the American Boat and Yacht Council, and the International Regulations for Preventing Collisions at Sea (COLREGS) for large vessels,

all agencies use the same standards to define acceptable wavelengths for each color.

These guidelines for chromaticity are defined using a colored X-Y diagram (below) developed by the International Commission on Illumination (CIE, for its French name). To be compliant, the green, red, white, or yellow lights must have wavelengths (measured in nanometers) that fall within certain boundaries on the diagram. Each corner of the boundaries are defined by X and Y coordinates. The coordinates can be found in Section 33 of the Code of Federal Regulations (CFR).

1931 CIE Chromaticity Diagram



Effectively, the rules allow slight shifts to either the blue or yellow side of green.

eted lens, are common to this design.

Just before going to press with this review, Signal Mate sent us its new production version of this lamp. Like the pre-production unit, the LED circuitry is enclosed in a polycarbonate cylinder, but it now incorporates O-ring seals and 3M 5200 adhesive to better cope with thermal expansion and contraction. Heat dissipation and RFI suppression have been improved, and the

Signal Mate 2-nm Tri



overall fit and finish have been raised a notch. The light is certified to USCG and American Boat and Yacht Council (ABYC)-16 standards.

**Bottom line:** The \$359 Signal Mate tri-color is a cost-effective option with a good five-year warranty, and the new version boasts some necessary improvements.

### LED BULBS

The new breed of LED bulbs can add efficiency

to those old Aqua Signal, Hella, and Perko incandescent nav lights that have been serving boats for decades. These plug-and-play conversions from incandescent to much more efficient LED technology are capturing market share, and the degree of this success has inspired Aqua Signal to come out with its own single-diode LED light and a new line of LED products. For those with older lamps such as the venerable Aqua Signal 40 tri-color, the following three bulb options represent good examples of what’s available in the realm of LED conversions.

### DR. LED

The Dr. LED Polar Star 40 replacement bulb for the Aqua Signal 40 lantern comes with an interesting note. According to the Seattle firm, “a white LED should not be used behind colored lenses.” And to that end, its LED replacement bulb has three distinct color-enhanced sectors indigenous to the bulb itself. These are not stand-

alone red, green, and white sectors, but instead are color-enhancing segments that ensure that red is red and green is a bright and deep shade of green. This reduced the bulb’s hotspot.

The bulb is designed in the U.S., made in China, and meets the 2-nautical-mile visibility, chromaticity, and other demands of the ABYC/USCG standards. It was the lowest current-consuming light in our test (0.1 amps), and though not the brightest, it was visible and color recognizable at the 2-mile range.

**Bottom line:** Middle of the pack price-wise, this \$50 current miser gets a PS Budget Buy among LED bulbs for conversions.

### LUNASEA LIGHTS

This well-sealed, wedge shaped, waterproof bulb uses separate LEDs for each color zone. The red sector held six LEDs, and the green four. Light-meter readings indicated that the red sector was a bit brighter than the green sector during tests. At distances beyond 100 yards, the discrepancy was not noticeable visually. Both segments could be

## SYSTEMS



Aqua Signal Series 40

The LED bulbs we tested from Dr. LED, LED Shop, and Lunasea would all be effective replacements for the incandescent bulbs of the popular Aqua Signal Series 40 tri-color mast-head light housing.

seen at the 2-nautical-mile range. This bulb seemed to only need a clear housing because of the excellent chromaticity match, but without being placed in a tri-lens housing, it had a rather large overlap of red and green. We noted that the red and green (bow-on aspect) covered an arc of more than 20 degrees. But by placing the tri-color lens over the bulb, the overlap was brought into an acceptable 10-degree range, creating a bright, very distinguishable tri-color light.

The Lunasea bulb was the only one in its group with the ability to keep shining even if one of the multiple diodes failed.

**Bottom line:** One of the brightest LEDs tested, the Lunasea light gets the *PS Recommended* pick among bulbs for its top performance and lifetime warranty, the only test product to offer one.

### LED SHOP

Distributed by the Australia-based LED Shop, the white BAY-15D bulb we tested was a cluster of 15 diodes in pentagonal array of three vertical diodes per segment. This bright-white light makes a superb anchor light, and the LED Shop also recommends it as a replacement bulb for the Aqua Signal Series 40 tri-color light.

In our testing, it provided a bright red and green sector, but its colors were not as saturated as the color-specific bulbs by Dr. LED and Lunasea.

Testers' biggest concern was the fact the bulb isn't properly sealed. This does afford better heat dissipation, a key factor in LED longevity, but we prefer sealed bulbs.

However, the BAY-15D's \$27 price tag, its brightness and minimal RFI make it a bargain as an anchor light bulb.

**Bottom line:** Although inexpensive and a good performer, the BAY-15D was held back by its lack of a good seal.

### CONCLUSION

After an inordinate amount of light looking, we came up with a few important findings and a firm belief that LED illumination for a masthead tri-color makes great sense.

In the lantern category, we saw two big pluses and one significant drawback. The first big win is full brightness coupled with a huge energy savings—something we found in all three units tested. The second plus is the combination of a wide tolerance to voltage changes and a very long expected lifespan (manufacturer claimed). These features help soften the final blow: a price tag of considerable heft. (The lanterns range in price from \$340 for the OGM to \$689 for the Lopolight.)

When all was said and done, we put the Lopolight ahead of its competitors because of its crisp, even light, its well-delineated zones, low RFI, and well-designed and manufactured housing.

In the three-way battle of the bulbs, Dr. LED's Polar Star 40 performed head-to-head with Lunasea's wedge-shaped multi-diode lamp and the LED Shop's unsealed white bulb in what could be called a photon finish. Determining a top pick came down to the nitty-gritty.

Lunasea and the LED Shop bulbs were a little brighter, but the Dr. LED was a little more current miserly. And then there is the added benefit of the Lunasea's ability to maintain illumination even if one or two diodes bite the dust. The Dr. LED and the LED Shop bulbs both come with one-year warranties, while Lunasea offers a lifetime warranty.

Although the LED Shop bulb tested as the brightest, most efficient, and least expensive, it isn't sealed. So testers gave the Dr. LED bulb our Budget Buy pick and the Lunasea bulb the *PS Recom-*



Lunasea



Dr. LED



LED Shop

mended pick in this group.

If you already have a sound, well-sealed Aqua Signal 40 tri-color mast-head light or Perko or Hella equivalent with a current-hungry incandescent bulb in place, upgrade to an LED bulb. Our picks are the Dr. LED or Lunasea. If you're starting from scratch, consider the Lopolight LED lantern or the more moderately priced Signal Mate. In either case, you'll enhance your boat's visibility and take another important step forward in collision avoidance. ▲

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