DEFENSE STANDARDIZATION PROGRAM

CASE STUDY

Army Tactical Vehicle Blackout Light

This case study describes how the U.S. Army Tank-automotive and Armaments Command (TACOM) solved the Army's problems with vehicle blackout lights by developing a new, highly reliable blackout light system that improves safety and security, reduces cost, and fits every heavy tactical vehicle in the Army's inventory.

Army Tactical Vehicle Blackout Light
Standardization Case Study

New Light Improves Safety and Reduces Logistics Footprint

Background and Problem

Gaining military advantage often requires that military convoys move under the cover of darkness. Vehicles must operate with their standard headlights and taillights off, relying instead on blackout (BO) lights to provide enough light for driving, while limiting horizontal and vertical illumination to prevent detection by the enemy.

Army vehicles have two types of BO lights: marker lights and driving lights. BO marker lights indicate the position of a vehicle to other drivers in a convoy but do not illuminate the road. (Marker lights also serve as turn signals during normal conditions.) BO driving lights furnish a low, diffused light beam designed to be invisible to airplanes flying at altitudes greater than 400 feet, while providing enough light for vehicle drivers to see the terrain directly in front of them.

For more than 20 years, TACOM engineers have received reports from drivers in the field that the BO driving lights did not provide adequate illumination for safe driving. Blackout light design has always required a difficult tradeoff between providing enough light to enable operations and minimizing the risk of enemy detection. Unfortunately, traditional Army vehicular blackout lights do not perform particularly well in either domain.

To make matters worse, the traditional blackout lights have a high failure rate; they are notoriously unreliable. Failure rates are high because the 24-volt incandescent bulbs used in the lights require a very thin filament, making the bulbs more susceptible to burnout and to vibration failure—a problem inherent to the design of military vehicles and the various types of terrain they traverse.

In addition, 94 percent of the energy produced by the incandescent bulbs is heat, so an enemy can easily detect the heat signatures of vehicles operating with such BO lights. The likelihood of detection is enhanced through the use of low-light, image enhancers, or spy scopes—technologies that did not exist when the blackout lights were originally developed. Hence, convoy operations that were once invisible to spotter planes became visible to enemy reconnaissance because of the infrared (IR) emissions from the blackout lights.

Finally, the traditional blackout lights used on Army heavy tactical vehicles come in a wide variety of shapes and sizes unique to each vehicle. The proliferation of many different blackout lights results in high logistics support costs, reduces the availability of replacement parts, and degrades unit readiness.

The poor visibility provided by the frequently unreliable and failure-prone incandescent bulbs—the only viable technology available when the

BO lights were originally designed—places the safety of our soldiers, both in peacetime and in conflict, at risk. However, recent significant improvements in another commercial technology—light emitting diodes, or LEDs—gave the Army an opportunity to solve many of the problems of incandescent blackout lights and, at the same time, deploy standardized BO lighting systems across multiple vehicle platforms. TACOM, through its Heavy Tactical Vehicle Program Office, took advantage of that opportunity by undertaking the development of new-generation LED blackout lights for three heavy tactical vehicle systems: Palletized Load System (PLS), Heavy Equipment Transporter System (HETS), and Heavy Expanded Mobility Tactical Truck (HEMTT).

Approach

To develop an LED blackout light for the Army's tactical vehicles, TACOM established a project team consisting of TACOM engineering personnel, personnel from commercial suppliers, independent military testing personnel, and users.

- TACOM provided both engineering and testing guidance throughout the development stages, specifying performance parameters and establishing limits and testing requirements.
- Team members from the private sector included engineers from a small supplier of commercial, LED-based marker and signal lights who developed the prototype BO marker and driving lights.
- Military testing personnel independently verified the prototype lights' compliance with requirements.
- Users, or customers, included convoy drivers at several Army installations who subjectively validated the quality of the new blackout driving lights.

An experienced engineer and veteran of many vehicle lighting-system projects at TACOM led the team.

The project team's objective was to develop a blackout lighting system that increased the visible light for drivers, eliminated the notorious heat signature, and increased reliability. In addition, the team wanted the new lights to be backward compatible, which meant that they would have to fit on all fielded PLSs, HETSs, and HEMTTs—a significant challenge because many versions of these vehicles date back to the 1940s. This requirement drove a one-size-fits-all solution from the project's inception.

The team began its work by researching LED technology, comparing it with other lighting technologies. The team found the following:

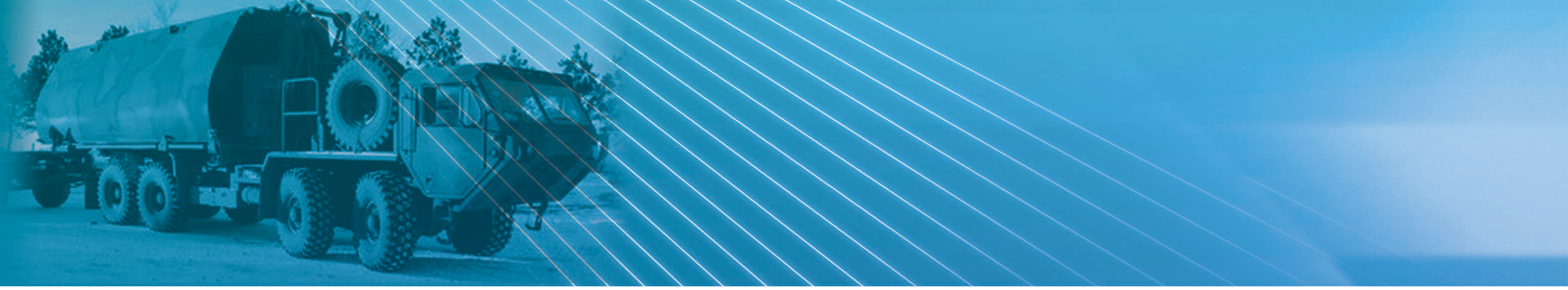
- LEDs produce more light than incandescent bulbs and use a smaller amount of electrical current. LEDs use 1/10 to 1/3 of the electrical current used by a comparable halogen light system. Increased energy efficiency means that an LED-based system places less demand on vehicle electrical systems, alternators, and batteries, thereby increasing the useful life of these systems.
- LEDs produce little heat. Therefore, a LED-based blackout-lighting system is IR secure and invisible to enemy spy scopes.

- LEDs are more reliable than incandescent bulbs because they do not have a filament. Their lack of a filament makes LEDs more rugged and tolerant of the harsh operating conditions typical of the military environment. Ordinary incandescent lights use electrical current to heat up a very thin filament, which glows to make light. In contrast, LEDs use a simple semiconductor that converts the electrical energy into light energy when electrical current causes a chemical reaction.
- An LED-based system is more durable, burning for up to 100,000 hours or 11 years. The maximum life span of the incandescent bulb used in the old blackout lighting system is 300 hours. Given this difference, users would replace 330 incandescent bulbs before replacing even one LED. Using reliable LED-based blackout lights will reduce parts demand on defense supply operations.
- LEDs operate across a wide voltage range instead of a specific voltage. This means that LEDs can work in both 12- and 24-volt

environments, making it easier to standardize the lights across different vehicle platforms. Because LED technology is flexible, upgrading an LED-based BO lighting system to be compatible with future higher voltage systems (manufacturers plan to shift to a 42-volt system in 2010) is a relatively simple process.

Military and Commercial Standards

Having confirmed the suitability of LED technology for blackout lighting systems on Army tactical vehicles, the team decided on a development strategy that included complying with existing military and commercial standards to guarantee interoperability with vehicles used by NATO mem-



bers and with commercial vehicles. To provide guidance and testing parameters for the BO light designs, TACOM selected NATO Standardization Agreement 4381, Blackout Lighting Systems for Tactical Land Vehicles. The team based its development work on STANAG 4381 because it offered several important benefits:

- It provided design and testing parameters useful for developing a replacement system.
- It automatically guaranteed interoperability with all NATO members.
- It increased design flexibility by permitting a range of light output. This flexibility made it easier for the project team to develop a prototype that would strike the optimal balance between illumination and safety.

The team also wanted to ensure that the lights would meet commercial and Department of Transportation (DOT) requirements. DOT's Federal Motor Vehicle Safety Standards (FMVSSs) are regulations that define minimum safety standards for motor vehicle equipment. The project team used FMVSS 108, Lamps, Reflective Devices, and Associated Equipment, developed by the Society of Automotive Engineers for DOT, to guide the development of "road-worthy" dual-purpose front marker lights.

Private-Sector Role

The team worked with Oshkosh Truck Corporation, a prime contractor for the Army's heavy tactical equipment, to identify highly qualified commercial LED suppliers to participate with the TACOM project team. Truck-Lite Corporation, a commercial supplier of lighting systems and recognized as a lead designer and manufacturer of LED solutions, was invited to work with the team.

Initially, because of its small size and inexperience as a DoD supplier, Truck-Lite was reluctant to participate on the development project but eventually agreed to join the team. Truck-Lite made a significant contribution to the development of the blackout driving and marker lights because of its experience with state-of-the-art LED solutions and its familiarity with DOT standards. Ultimately, Truck-Lite produced four prototype all-LED BO driving lights, each with a different light output.

Customer Input

The TACOM engineers and their commercial counterparts on the project team worked with military customers—vehicle drivers from Fort Carson, CO—to understand user requirements and to document the diversity of front-end mounting mechanisms used for the BO driving lights on the heavy tactical vehicles in the Army's inventory. The objective was to design a single mechanism to fit all of the diverse front-end configurations.

The team documented the mountings for 29 different vehicles (mostly large trucks and cranes). Upon completing its examination, the team concluded that variations in the mounting attachment mechanism across vehicle platforms would make designing a generic backward-compatible BO drive light an extremely difficult challenge. Undaunted, the team developed several prototype blackout driving lights before arriving at a viable solution. Subsequent testing and discussions with users at Fort Carson resulted in the development of a one-size-fits-all mounting mechanism that suits all heavy tactical vehicles in the Army's inventory.

Prototype Testing

The project team tested the blackout marker and drive lights extensively, using a combination of objective and subjective tests. STANAG 4381 provided guidance regarding the objective performance parameters that needed verification through testing. Because the STANAG allows for a range of light output, the project team tested the prototypes against increasingly higher light output thresholds to ensure both compliance with the STANAG and customer satisfaction.

Engineers at the Automotive Test Instrumentation Facility at Aberdeen Proving Ground, in Aberdeen MD, conducted a series of tests to independently verify compliance with requirements. The test results confirmed that the prototype designs were within tolerances specified by NATO STANAG 4381.

Customer Field Testing

The project team field tested the BO driving light at Camp Grayling, MI. The team selected this installation because it has a 5.3-mile course designed to train convoy operations, and Army units use Camp Grayling to practice convoy operations under blackout conditions.

TACOM installed 30 first-run production BO drive lights on PLS trucks for soldier evaluation. TACOM briefed the soldier drivers on the new lighting design improvements and provided a survey questionnaire for the drivers to complete. For several nights, the soldiers drove the PLS trucks over the blackout course using the new drive lights. The response on the survey questionnaires was unanimous: the soldiers finally had enough light in blackout mode to adequately see the terrain in front of them.

The field tests also compared the performance of vehicles equipped with the old blackout lights with those equipped with the new ones. The team recognized that although these test results would be subjective, positive user feedback would strengthen the already favorable engineering test results achieved by the Automotive Test Instrumentation Facility. Moreover, a favorable reaction

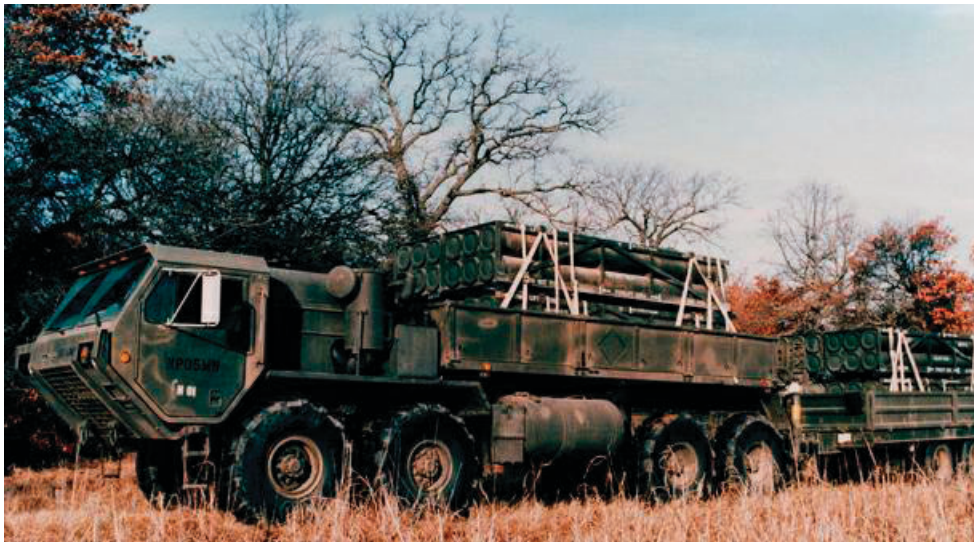
would accelerate (through word of mouth) the acceptance of the new BO lights across Army installations nationwide.

Vehicle drivers, using subjective test procedures, demonstrated that trucks equipped with the old system did not adequately illuminate beyond 10 feet. That meant that a driver could not see 10 feet in front of the moving vehicle—an inadequate distance to operate the vehicle safely. The drivers reported that vehicles equipped with the new blackout driving light extended the driver's field of vision out to 55 feet.

Outcome

The work of the project team resulted in the production of four new LED external lighting assemblies—marker and driving lights. The four lighting assemblies have been inserted, by engineering change proposal, into the current production of the PLS, HETS, and HEMTT. In addition, program managers for the HMMWV (High Mobility Multipurpose Wheeled Vehicle) and the FMTV (Family of Medium Tactical Vehicles) are committed to using the new external lighting assemblies on their future production vehicles.

By using LEDs rather than incandescent bulbs, the team was able to increase the visible light for drivers; drivers using the new lights reported dramatic improvement. At the same time, because LEDs produce little heat, the new BO lighting systems are IR secure and invisible to enemy spy scopes. Drivers can now see without being seen during blackout conditions, improving the safety and effectiveness of convoy operations.



The new systems also are dramatically more reliable than the old incandescent lights, and they are backward compatible with already-fielded PLSs, HETSs, and HEMTTs. The reliability of the new BO lighting systems and their compatibility across numerous Army vehicle systems significantly reduce the life-cycle cost.

Benefits

The Army will realize many benefits from the new LED lighting systems:

- Improved safety and training readiness
- Improved equipment readiness
- Better performance at a lower unit cost
- Lower inventory cost.

Safety and Training Readiness

Troop convoys participating in training exercises and combat situations are safer when using heavy equipment vehicles with the new LED blackout lights. In addition, the new lights increase equipment readiness, decrease operation and support costs, and reduce the logistics footprint:

- Because drivers can see where they are going, convoy operations are more effective during blackout conditions, and the safety of convoy and ground operations increases. LED technology illuminates the driver's field of vision five times further than the incandescent-based system (10 feet for the old blackout driving light versus 55 feet for the new one).
- Combat and training accidents decrease because of improved visibility.
- IR security reduces the probability of detection and enhances operational safety during blackout conditions.
- It is easier to meet annual convoy training requirements for practicing blackout operations, because the LED-based product is more reliable. Units can train for BO conditions more effectively, yielding improvements in vehicle readiness and vehicle operator training.

Equipment Readiness

Equipment readiness is significantly improved with the new LED BO lights:

- Blackout lighting equipment is more reliable because the LEDs are very durable and perform well over an 11-year life span.
- LED technology uses less energy to produce more light, placing less of a strain on heavy tactical vehicle electric systems.
- The one-size-fits-all product facilitates using a standardized product across all heavy tactical vehicle platforms and simplifies repairs and maintenance training.
- Equipment condition readiness improves because BO lighting equipment used on heavy tactical equipment is operational when needed; consequently, unit readiness improves.
- The new blackout light is more reliable, placing a lower demand on the defense supply chain. The Army would have to replace some 330 of the old blackout lights for every LED-based blackout light that must be replaced.

Table 1. Estimated Expenditures for New Versus Old Blackout Lights

Vehicle	Number of exisiting units	Number of new units	Total number units	Estimated cost with incandescent blackout light ($90/unit)	Estimated cost with LED blackout light ($50/unit)
Palletized Load System	2,729	117	2,846	$256,140	$142,300
Heavy Equipment Transporter System	1,722	0	1,722	$154,980	$86,100
Heavy Expanded Mobility Tactical Truck	9,476	744	10,220	$919,800	$511,000
Total	13,927	861	14,788	$1,330,920	$739,400

Performance and Unit Cost

The new LED BO light costs $50 per unit, $40 less than the incandescent lights. The Army plans to fit all existing and new heavy tactical vehicles with the new blackout lights. Table 1 compares the estimated expenditures that result from this decision. As the table shows, by deploying the LED lights, the Army will significantly reduce its total expenditures for vehicle lights.

Table 2. Cost of Four Obsolete Blackout Light Parts

Item	Quantity	Cost/unit	Annual cost
Headlight part A	1,869	$60.95	$113,915.00
Headlight part B	281	$51.52	$14,477.00
Headlight part C	7,316	$30.51	$223,211.00
Headlight part D	1	$7.86	$7.86
Total	9,476	$150.84	$351,610.86

Inventory Cost

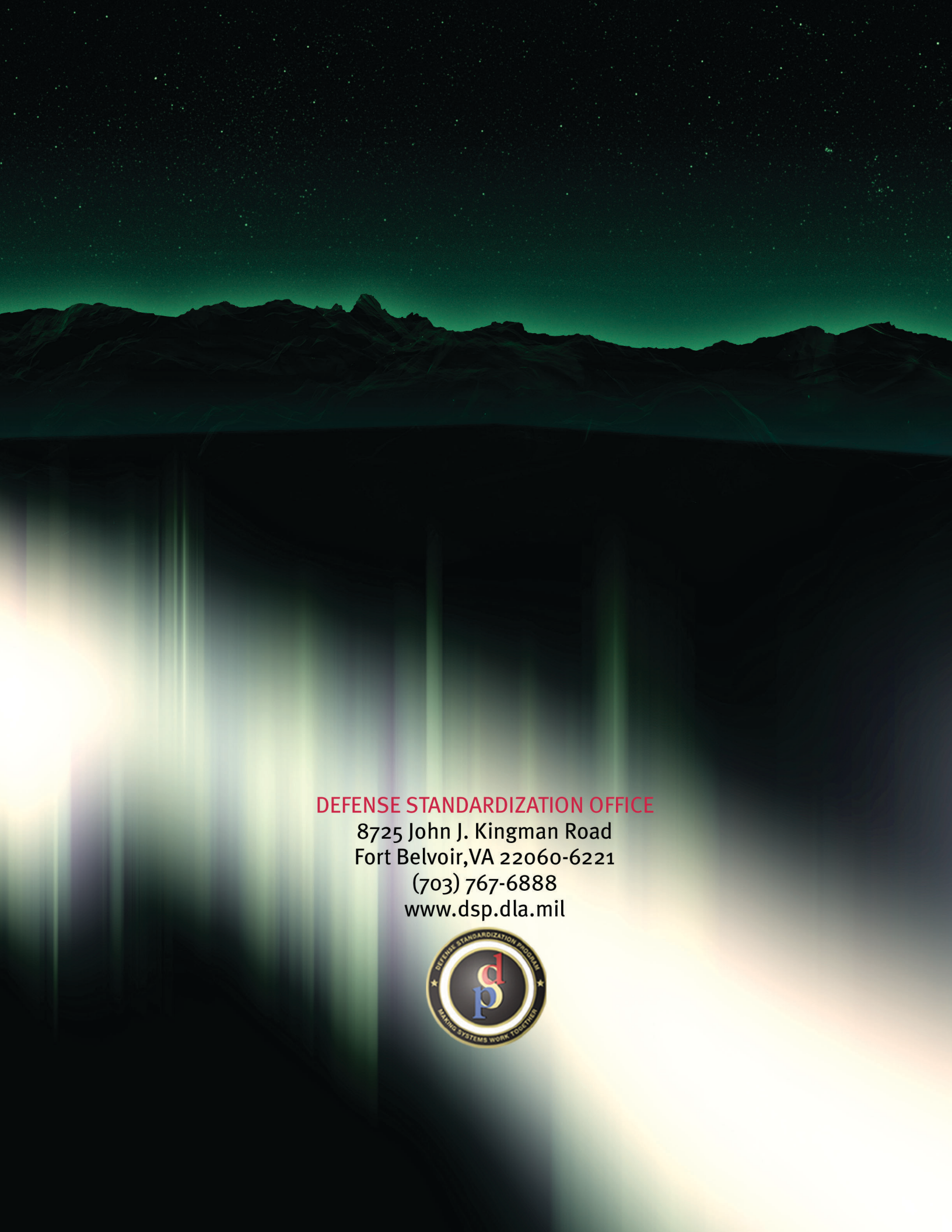
The new LED blackout light assembly removes four items related to the old blackout light from the Defense Logistics Agency inventory. These parts represented an annual demand of 9,467 units with an annual cost of $351,611, as shown in Table 2. Those items have been replaced by the new LED-based blackout drive light, at a substantially lower cost. Acquisition, supply chain management, and equipment maintenance expenditures, which we do not estimate, will decline as well because of reductions in the ordering levels, inventory holding costs, and equipment repair activities.

The new LED blackout lighting system went into production in June 2002. As the word spreads, more vehicle program managers are taking advantage of the new LED-based blackout lights. Standardized blackout lighting designed to fit all the platforms in the tactical vehicle inventory makes this possible. The Army's new FMTV and the HMMWV will also adopt the new LED-based blackout lights. As more vehicles adopt and use the new technology, the savings will continue to mount.

Lessons Learned

The following are key lessons learned:

- Market research plays an essential role in identifying the best technology. Market research helped the team verify that LED technology could solve the problem.
- Commercial technology can satisfy military requirements. The team engaged a commercial supplier who had relevant experience developing commercial lighting systems with the technology.
- Customer involvement, prototype development, and testing help improve a product and increase its utility across platforms. Involving customers from Fort Carson in the development of the blackout lights resulted in a product that meets customer requirements and provides standardized solution across all heavy tactical vehicles.
- Teamwork among engineers, testers, suppliers, and users is essential. Teamwork resulted in a product that is achieving rapid acceptance by Army users who for too long operated with suboptimal blackout lights.



DEFENSE STANDARDIZATION OFFICE
8725 John J. Kingman Road
Fort Belvoir,VA 22060-6221
(703) 767-6888
www.dsp.dla.mil