Rising Stars

Safety may be the only thing inconspicuous about light-emitting diodes.

BY WAYNE ROSENKRANS

Background, solar-powered LED runway edge light system; foreground, LED runway guard lights.

Guiding flight crews on the ground with light-emitting diodes (LEDs) coincides with airports' growing realization of how much this technology offers beyond mere replacement of red obstruction lights and blue taxiway edge lights. Each LED among those arrayed in an airfield lighting fixture is a semiconductor chip. When electric current passes through its thin layers of semiconductive material, the material emits either white light or one saturated color of light. Often, LEDs — also known as *solid-state lighting (SSL)* — cannot be made visually identical to their incandescent counterparts.[1]

As soon as required LED colors and sufficient light output became available, some in this decade, designers had to overcome challenges such as insufficient heat output to melt snow and ice in some airport environments and the occasional unplanned circuit shutdown. Today, designers can specify taxiway and runway guidance devices that outshine earlier xenon flash tubes and incandescent-filament lamps, such as full-spectrum tungsten-halogen lamps with color-filtered lenses.

Many aviation-safety advantages of LEDs seem indirect, not obvious, but that has not dissuaded airports or manufacturers from seeking new applications. A year ago, the airport subcommittee of the U.S. Federal Aviation Administration (FAA) Research, Engineering and Development Advisory Committee recommended that the agency and the Lighting Research Center at Rensselaer Polytechnic Institute continue to cooperatively pursue the development of LED technology for airport lighting through fiscal year 2010.[2]

Fixture: Siemens Airfield Solutions Runway: Carmanah Technologies

Encrypted wireless communication remotely controls a self-contained, solar-powered LED airfield light with integrated battery and energy management.

One indirect safety advantage is the newfound feasibility of installing permanent, temporary or backup airfield lighting at airports where none existed. A 2008 FAA advisory circular (AC) for one type noted reasons that apply to many types: "When coupled with recent technology advances in photovoltaic solar panels and associated components like batteries, solar-powered LED [obstruction] lights … in many cases can be designed for half the cost of [extending] a commercial power line."[3]

Solar-powered LED obstruction lighting systems have been installed at airports throughout the United States, the FAA said. "With no trenching or cabling required, a two-person crew can install [lighting to establish] a fully operational 5,000-ft [1,525-m] runway in one hour or less, making it ideal for use during emergencies or natural disasters," said Carmanah Technologies, a manufacturer. Some airports also have focused on taxiway/runway guidance upgrades.

Another indirect safety advantage is compatibility of LED synchronization and fixture-status monitoring with runway safety initiatives, including advanced surface movement guidance and control systems. Addressable runway guard lights "use communications on the series circuit to synchronize the flashing of the lights in a hold bar, and also use communications on the circuit to collect status of the fixtures to ensure the operational state is known," an FAA report said.[4]

Besides safety, airports turn to LEDs for several reasons, including reduced energy consumption; a typical operating life 10 times longer than incandescent sources and, for example, solar- and battery-powered taxiway lights that can go five years without significant maintenance; reliability/durability, including greater resistance to vibration and shock/impact than incandescent lamp filaments; relatively small size and weight; instantaneous on/off capability that shaves critical milliseconds from human reactions to a threat; and directional control.

One of the earliest FAA research projects on LED airfield lighting explored displays of numbers and symbols to supplement/replace paint markings on airport movement areas, and found that ice and snow could obscure the LEDs.[5] The need for auxiliary heaters to be incorporated into some LED taxiway edge lighting prompted further FAA-sponsored research.

The Lighting Research Center found that positioning blue filters over white incandescent lights is a relatively inefficient way to consume energy, compared with installing modified, aviation-blue glass-filter optics over blue LEDs. "To meet FAA regulations for weatherability, some LED-based fixtures incorporate electric heaters that, when switched on during winter months, nearly negate the energy-savings benefit of converting to LED sources," the report said. The most successful alternative was a prototype fixture with eight blue LEDs around a circular aluminum heat sink. This enabled convection and conduction of sufficient heat — melting ice and snow at ambient temperatures of minus 40 C (minus 40 F) — to the fixture optics from the power supply–LED connection point.[6]

The center also studied LEDs for remote airports that have insufficient electrical infrastructure for conventional fixtures. Pilots evaluated simulated nighttime conditions by

Carmanah Technologies

observing a scale model that varied the intensity, color, flash pattern, viewing angle and spatial arrangement. "Subjects viewed different lighting scenarios and were asked to locate the airfield and determine the runway's orientation," the report said. "Researchers measured subjects' elapsed time, accuracy rate and confidence level in locating the appropriate airfield." Prototype LED fixtures for runways were installed for flight tests in Alaska and North Dakota to validate the laboratory results.

LEDs can affect the level of safety in airport maintenance. Workers spend far less time exposed to hazards in the airport movement area as they check, but rarely need to replace, LED fixtures, the argument goes. "There is very low voltage inside the LED runway end identifier lights [REIL] versus the 2,000-volt direct current common in traditional xenon fixtures," said Siemens Airfield Solutions.

Improved conspicuity also has been cited by government and industry. Siemens said that its elevated and in-pavement LED runway guard lights, for example, can be programmed to emulate incandescent lights or set for instant on/off operation with 45 to 50 flashes per minute of the alternating yellow lights. FAA researchers have validated, by airport field testing of elevated runway guard lights, that this characteristic is perceptibly superior to the longer rise and decay times of standard incandescent fixtures.

LED runway end identifier lights.

Ongoing FAA research includes collecting data to establish "acceptable LED-based performance criteria to take the place of traditional lighting standards," said Don Gallagher, the FAA's visual guidance research manager. "The introduction of economical and efficient LED [airfield lighting] represents the greatest potential change in the lighting of airport visual aids in decades. … We need to further study how LED technology interacts when interspersed with standard incandescent lights on airport circuits; how LED intensity changes can be effected; and how LEDs can be seen on an enhanced vision display [on the flight deck]." Airfield lighting specialists from Canada, France, Germany, Italy and the United States meanwhile have been collaborating on the Visual Aids Working Group of the ICAO Aerodrome Panel. "The [working] group will be providing guidance material on using LED technology in visual aids that will be included in the *ICAO Aerodrome Design Manual, Part 4 – Visual Aids*," the FAA said.[7]

LED-related circuit instability prompted the FAA to begin recommending in 2005 system design and maintenance solutions. A related change likely will be the first standardized, low-power airfield circuits that will match LED characteristics.

When LED fixtures began to be retrofitted at U.S. airports, some of their constant current regulators (CCRs) — a voltage-protection device that maintains the current at a specific level — became unstable and automatically shut down airfield circuits. "Some CCRs turn off due to overvoltage or overcurrent because of LED taxiway edge lights," said an FAA report on the issue. "There are no standards for LED fixtures that require any specific load behavior on the part of the fixture. … When designing circuits that include LED fixtures, the peak and nominal volt-ampere (VA) loads should be considered to assure adequate margins. … Extreme care should be taken when considering the use of LED fixtures on circuits that share other high initial peak VA components."

Notes

1. Navigant Consulting. "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications." Report prepared for the U.S. Department of Energy. November 2003.
2. Hansman, R. John. Letter to FAA Administrator Robert Sturgell on behalf of the FAA Research, Engineering and Development Advisory Committee. Nov. 7, 2007.
3. FAA. "Runway and Taxiway Fixtures." Advisory Circular 150/5345-46B (L-804).
4. Cyrus, Holly M. "Light Emitting Diode Taxiway Edge Lights Emissions Evaluation." FAA report no. DOT/FAA/AR-TN05/10. March 2005. Cyrus; Nadel, Jess. "Light Emitting Diode Taxiway Lighting Effects on Constant Current Regulator Stability." FAA report no. DOT/FAA/AR-TN08/29. May 2008.
5. Gallagher, Donald W. "In-Pavement Light Emitting Diode (LED) Light Strip Evaluation." FAA Interim Report no. DOT/FAA/AR-01/39. August 2001.
6. Gu, Yimin; Baker, Alex; Narendran, Nadarajah. "Investigation of Thermal Management Technique in Blue LED Airport Taxiway Fixtures." In proceedings of the Society of Photo-Optical Instrumentation Engineers, Seventh International Conference on Solid State Lighting, 2007.
7. FAA. "Runway Incursion: Making Runway Incursions a Thing of the Past." *R&D Review.* Issue 2, 2007.