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Lighting Strikes

Realistic lighting conditions are crucial to tests of the readability of flight deck displays.

BY CLARENCE E. RASH

When pilots are taxiing their aircraft to a runway for takeoff, little if any thought is given to the effort that has gone into ensuring that the instruments are readable — that is, until they aren't. One of the most challenging display lighting situations occurs during the day, with full sunlight reflecting off the displays. Another occurs at night, for helicopter pilots using night vision goggles (NVGs). Inadequate instrument lighting design can make reading the displays impossible in either situation.

Flight decks are affected by a range of lighting conditions, often during a single flight. The lighting environment is derived from three sources:

- Outside ambient lighting, which can be both natural and artificial, is dominant. Natural contributors are the sun, the moon and stars. Outside artificial light sources include runway lights, surrounding operational lighting and city/industrial background lights;
- Interior compartment lighting, which may include instrument-panel lights and overhead lights; and,
- Supplemental utility lighting, which pilots may introduce in the form of flashlights, chemical light sticks and other auxiliary lighting.

Whatever the lighting environment, pilots must be able to access instrument data whenever it is needed. During the day, there must be sufficient illumination without glare, adequate contrast between the displayed information and the background, and acceptable color rendition.[1]

At night, flight deck lighting must provide uniform illumination throughout the crew station and a minimal level of illumination to allow pilots to acquire information, to activate switches and controls, to consult navigational charts and yet not degrade the ability to perform additional visual tasks outside the flight deck, such as detecting and identifying obstacles, locating landmarks and scanning for other aircraft.

Instrument lighting must not interfere with the operation of NVGs.

Evaluation Challenge

The many types of display technologies, lighting conditions and visual tasks in today's aircraft place great demands on the lighting designer. Designs are driven and complicated by the limited space of the modern crew station, the differing operating principles of various display technologies and the wide range of ambient lighting conditions under which displays are used. Nevertheless, the actual lighting values achieved on the flight deck are most important. Test and evaluation engineers validate whether the displays provide the required luminance (brightness), contrast, color and other visual display characteristics that define acceptable readability.

The necessary validation must be accomplished through a set of assessments using quantitative tests and operator evaluations of readability and legibility in an authentic set-up of all flight deck displays, instruments and control panels under a comprehensive complement of realistic ambient lighting conditions.[2]

These quantitative assessments require instruments to measure visible light, color and specific forms of light energy. The first analysis of display performance involves basic measurement of the aircraft instruments themselves, conducted in darkened laboratories. These results are compared with specifications and assigned a pass/fail rating. If the instrument display passes the qualification tests, it next may undergo limited user acceptance tests in flight deck mock-ups. Well-designed human factors studies and surveys are used to evaluate user performance in these controlled but not very realistic settings.

Although the tests can be arduous and require meticulous effort, they also are straightforward. Lighting measurements of any kind often are considered half science and half art, and the skills required to conduct the measurements are obtained more through experience than through training. But even the best test and measurement approach in artificial environments is an approximation of the actual performance that will be achieved in the real-world environment. This is especially true in aviation lighting.

The real challenge in validating the true performance of instrument displays lies in reproducing realistic lighting conditions that represent the lighting environments of full sunlight, dawn/dusk, moonlight and starlight.

Simulating the Sun

To provide realistic lighting conditions in a testing facility and to minimize the costs of testing, Alenia Aeronautica designed and built a sophisticated test and evaluation lighting facility at Turin (Italy) International Airport. The facility provides a cost-effective methodology for evaluating actual, full-scale, state-of-the-art aircraft displays under virtually the full range of ambient lighting conditions.[3]

The Alenia Aeronautica facility Sky Light Simulator (SLS) consists of 79 lighting panels and 112 reflective panels, a sun simulator and a cooling system. The lighting panels each contain a variable number of fluorescent tubes to reproduce the appropriate lighting condition. All panels are controlled by computer and can be configured for a specific sky luminance pattern. Lamp performance is stabilized and prolonged by a cooling system that recirculates the ambient air 60 times per second while maintaining the dome environment at 50 percent humidity and from 59 degrees F to 77 degrees F (15 degrees C to 25 degrees C).

The sun simulator uses a 12-kW lamp to illuminate the dome center. The simulator can be operated in two modes, either to reproduce the effect of direct sunlight into the cockpit or to reproduce a solar disk of the correct apparent size. An approximately 29-ft (9-m), two-axis, moveable mechanical arm allows the lamp of the sun simulator to be positioned at any location around the aircraft.

The effects of clouds are simulated by two lamp projectors used in conjunction with the light panels. This is most useful in evaluating a pilot's ability to discern symbology presented on head-worn — or helmet-mounted — displays.

Dawn and dusk illumination conditions are achieved by using another light projector.

By combining the various lighting simulations, many "worst case" lighting scenarios such as these can be created and tested:[4]

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- A daytime combination of direct sunlight, sky diffuse light and cloud-diffused light;
- A nighttime combination of moonlight and starlight;
- High ambient lighting, rear sun position;
- High ambient lighting, front sun position;
- Dawn/dusk, front sun position; and,
- Low ambient lighting, with or without NVGs.

Moon and Stars

With the emergence of NVGs in the civilian cockpit, lighting and its effects on pilot performance take on a new emphasis. Because modern NVGs amplify the intensity of light approximately 2,000 times, even small levels of light that cannot be detected by the human eye can greatly affect NVG performance — and, as a result, pilot performance.

NVGs are designed to allow pilots to view outside scenes under lighting conditions that extend down to the overcast starlight range. NVGs have automatic circuitry that increases or decreases their light amplification, or gain, in response to the level of outside ambient light. Unfortunately, NVGs are unable to differentiate between light originating outside the aircraft and inside. As a consequence, inadequate interior lighting design can negatively affect NVG performance by unintentionally reducing the amplification of exterior light as the NVGs respond to the specific cockpit instrument lighting. The possible outcome is that pilots have a reduced capability to view critical outside scenes, an outcome that may go unnoticed by the pilots.[5]

This unobserved effect of flight deck lighting on NVG/pilot performance makes evaluation essential when NVGs are the primary source of visual flight information. This simulation and testing under nighttime lighting conditions is one of the most difficult procedures.

To provide the unique lighting requirements needed for testing pilot performance with NVGs, the night system used by Alenia Aeronautica employs a dedicated specialized light source to simulate the nighttime moon and star conditions.

The nighttime projector consists of dual sets of halogen lamps and illuminates the flight deck indirectly. Black curtains reduce stray light — an essential quality for NVG evaluations — by blocking external light and absorbing internal reflections.

Aircraft, Trains and Automobiles

The SLS also tests actual, full-size aircraft over the simulator's full range of lighting conditions. Anna Russo, aerospace engineer with Alenia Aeronautica, said that the facility "can host a multitude of aircraft, both fixed- and rotary-wing, as well as automobiles and train locomotives." The facility is built on a 30-ton (27-metric ton) steel frame supporting a 12-m (39-ft) diameter spherical dome above a cylindrical drum.[6]

The structure has a specialized opening — about 10 m by 6 m (33 ft by 20 ft) — that accommodates the front fuselage of an aircraft. A customized system of doors and curtains completes the light-tight sealing needed for the lighting tests.

By reproducing an array of fully controllable lighting environments and presenting these conditions directly onto actual aircraft, the SLS has several advantages, including its availability regardless of outside weather conditions, its objectivity and repeatability in measurements and a full range of computer-controllable illumination levels.[7]

In addition to supporting lighting tests and evaluations for the aircraft industry, the SLS is a laboratory for other lighting testing activities, including architectural assessments, vision and psychophysical research, aeromedical research, and human factors and ambient lighting interactions.

To ensure safety during testing and evaluation activities, a number of sensors are deployed. Included are fuel vapor detectors and fire detectors located in the dome region and smoke and fuel detectors in the air-cooling system. A fire-suppression system incorporates foam dispensers and water sprinklers. ●

Clarence E. Rash is a research physicist at the U.S. Army Aeromedical Research Laboratory at Fort Rucker, Alabama, U.S. He has three decades of experience in aviation safety, operational performance and human factors issues.

Notes

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