**TATRC Highlighted Research Feature Article:**
**Soldier Mounted Eye-Tracking and Control Systems: Eye-Com Biosensor, Communicator & Controller**

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## In the Blink of an Eye

*The Eye-Com™ is an unobtrusive, wireless electronic device on an eyeglass-type frame that monitors and records head tracking and 20 eye measures.*

*Nevada neurologist Dr. William Torch is wearing the Eye-Com™ Biosensor Communicator and Controller he developed, which can detect drowsiness and trigger an alert to avoid an accident.*

Photos courtesy of Eye-Com Corporation

It's another routine nighttime surveillance. But the Black Hawk helicopter pilot has been pulling long shifts due to the nature of the mission. As he begins to blink drowsily, the

small, electronic biosensor within his goggles detects the change in eye movement and triggers an alert. The pilot turns over the controls to his partner, and instead of becoming another fatigue-related crash, the flight is completed without incident.

The possibilities for eye-tracking devices have never been more exciting: Detecting fatigue and calling for assistance to avert accidents in everything from truck convoys to high-altitude fighter planes to commercial aircraft carrying hundreds of passengers. Enabling seriously injured Soldiers to operate wheelchairs and speech devices by simply gazing in a certain direction. Enhancing target selection and detection through eye-controlled mechanisms.

Many of these are now possible through an unobtrusive, wireless electronic device on an eyeglass-type frame that is easily worn or fits conveniently under a helmet, visor or night-vision goggles.

This device, the Eye-Com™ Biosensor Communicator and Controller, brainchild of Nevada neurologist Dr. William Torch, is one of the many promising biomonitoring technologies supported by the U.S. Army Medical Research and Materiel Command's (USAMRMC) Telemedicine and Advanced Technology Research Center. TATRC coordinates a variety of research projects at private and public organizations throughout the country in order to put the latest medical technology to work for the nation's warfighters and veterans. It is supporting approximately 500 ongoing research projects.

**The Creation of Eye-Com**

Torch first envisioned Eye-Com in 1998 while attending to a paralyzed hospital patient who was on a ventilator in the intensive care unit. Glen was 34 years old and in a coma due to encephalitis. Torch recalls, "All of a sudden, he opened his eyes, looked right at me, and I knew he was engaged. He could blink to indicate 'yes' or 'no' to simple questions, but he couldn't communicate complex thoughts."

In addition to running his own practice in neurological and sleep disorders, Torch is also an inventor—and that inventor went to work. Could he focus an infrared beam on the eyelid to read the blinks and then connect this sensor to a buzzer? A trip to Radio Shack with a friend who knew electronics, and Torch soon had a detector that "read" the reflected light from closed eyes and buzzed for as long as they were closed. Shut them in short and long blinks and—presto!—the dots and dashes of Morse code. In the blink of an eye, Torch could give Glen the power to communicate all he was thinking. And Eye-Com 1 was born.

Always looking to the next challenge, Torch continued to ask questions and refine the Eye-Com with the help of a dedicated team of engineers and researchers.

Why didn't it work as well in brighter lighting conditions? He solved that issue by replacing the first simple detector with one that used high-frequency pulsed infrared light, such as used in a TV remote, and thus filtered out the regular streaming light that was interfering.

Did the eyelid closures detected by the Eye-Com light beam match those detected by EEG electrodes placed on the skin to measure the brain's electrical activity? Yes, which meant the Eye-Com could connect to an EEG machine to produce a perfectly synchronized wave readout without skin electrodes.

But could Eye-Com transmit wirelessly to the EEG machine? Torch and his colleagues built a transmitter and receiver that enabled them to monitor the eye movements from another room.

What else could Eye-Com transmit to? The team configured it to create Morse code-like signals on a computer, which converted the signals to letters on the screen. They learned they could send signals to any electronic device, turning it off and on via eye blinks.

Along the way, Torch realized that the Eye-Com could measure not only purposeful blinks, but normal ones. It could distinguish the longer blinks that accompany drowsiness and trigger an alarm to rouse the person—such as a vibrating seat or voice synthesizer. It could also send the alarm to a remote source such as 911 in case of loss of consciousness. In Eye-Com, Torch now had a wireless drowsiness detector that could prevent accidents by taking action before a driver or machine operator actually drifted into sleep.

**Proving Itself**

Through a variety of private and public funding, including a government champion in Democratic Senate Majority Leader Sen. Harry Reid (NV), Torch has taken Eye-Com into its eighth generation. The device now uses microchips and newly developed software to wirelessly monitor and record head tracking as well as 20 eye measures, from blinks to the size and speed of pupil dilation. It has evolved from a clunky apparatus to a miniaturized unit in a convenient eye frame.

Most importantly, in test after test, it works.

The Eye-Com received airworthiness certification for Black Hawk helicopter use after Army tests proved it could identify drowsiness in sleep-deprived pilots. The Air Force found that in simulated high-altitude, low-oxygen conditions, it predicted jet pilots' loss of ability to both accurately control their planes and discriminate enemy from friendly aircraft. The Navy put it in scuba masks and showed that it could identify Navy SEAL swimmer fatigue.

Torch's team created a simulator that has provided even more detailed data on Eye-Com's capabilities. He explains, " I moved a Dodge Ram truck cab into my lab, equipped it with Eye-Com technology and created a Drive Simulator with 150º wraparound scenery that can realistically depict boat, jet or auto simulated terrains. The Eye-Com is simply more reliable in more situations than a dashboard-mounted system, which fails when the driver turns his or her head away, has a lot of head movement or wears sunglasses or contacts. And it uses a nontrackable wideband signal, which ensures privacy."

**Saving Lives … and More**
Torch expects the Eye-Com will be in the field for all uses within two years.

Dr. Eva Lai, who manages the Biomonitoring Technologies portfolio at TATRC, notes, "The Eye-Com technology is different from other eye-tracking systems because it's wearable, portable, easy to use and works in all lighting conditions. It has such potential to benefit our Soldiers, not only by enabling them to perform their duties more efficiently and effectively, but also saving their lives. Additionally, Dr. Torch is using the technology to detect the effects of jet lag and shift work fatigue that reflect conditions in battlefield operations. This way we can predict when drowsiness may occur, taking prevention a step further."

She adds, "There is a lot of excitement about the many potential applications to be derived from this technology, as noted by a recent TATRC programmatic review panel consisting of physicians, scientists and engineers representing the military, academe, federal agencies and industry. The panel in particular was interested in its possible development for diagnosing traumatic brain injury. Accurate detection and treatment is a high priority in light of estimates that some type of brain injury could affect up to 70 percent of U.S. troops injured in Iraq. Alternatively, just think of what it would mean to a Soldier with limb loss to be able to continue contributing in some way—to still be a Soldier—through the use of eye-controlled assistive devices."

Adds Dr. Sylvain Cardin, who is managing this effort for TATRC, "The beauty of TATRC is that we can connect technology such as the Eye-Com with research in other fields in order to greatly expand its use." In the near future, Eye-Com will be working with the U.S. Army Research Institute of Environmental Medicine and UC Santa Barbara to further advance this technology and leverage the skills and expertise contained in this collaboration.

Potential Eye-Com applications extend from the military to all facets of civilian life. It could enhance educational software, video gaming and robotics. It could assist in better diagnosis of sleep disorders, attention deficit disorder and autism. And it could be used to study side effects of blood pressure medication or the effectiveness of various wakefulness treatments.

Says Torch, "Between 10 to 20 percent of all accidents are fatigue related. If Eye-Com can prevent the loss of life from even one truck or passenger plane crash or the environmental damage from one oil spill, it would all be worth it. And I am so inspired by the possibility that I could improve the quality of life for those with Parkinson's, ALS (Lou Gehrig's disease) or muscular dystrophy. I've worked with several paralyzed individuals—friends as well as renowned theoretical physicist Dr. Stephen Hawking—and the idea that I could let their spirit shine forth has really driven me."

So much potential, in the blink of an eye.