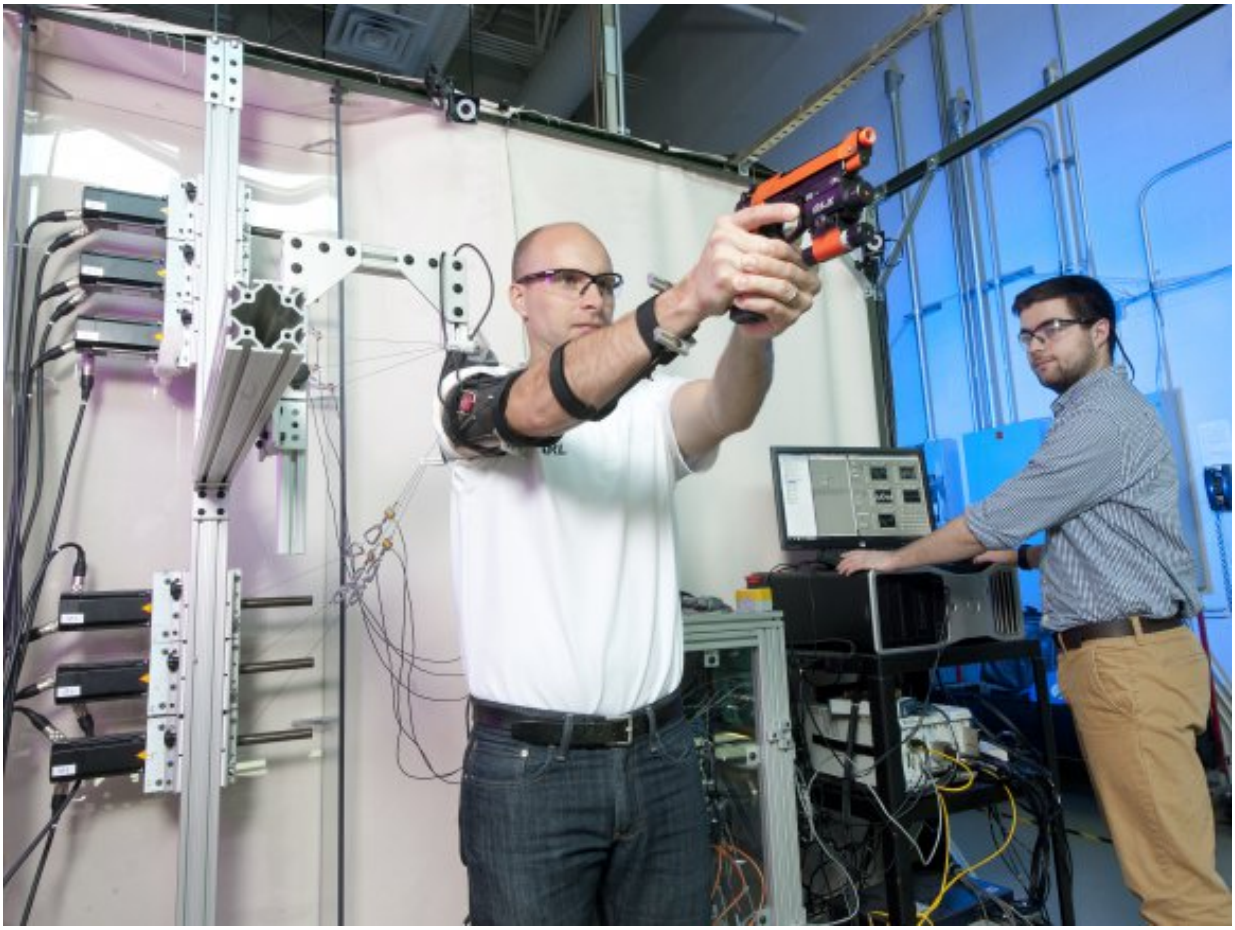
Mechatronic arm exoskeleton to train new soldiers to reach shooting proficiency

July 6 2015, by Joyce P. Brayboy



Dan Baechle, left, from the U.S. Army Research Laboratory Multifunctional Materials research team, has created a laboratory prototype of a device he designed to sense and damp out arm tremors for army marksmanship training. Credit: Doug LaFon

Robotic exoskeletons have been a science fiction theme and an engineering feat since the 1960s. Practical design techniques, which allow a fictional character to be stronger, more powerful or more functional intrigue engineers toward simplicity in futuristic innovation.

At the U.S. Army Research Laboratory, or ARL, Dan Baechle, a mechanical engineer, is testing MAXFAS, a mechatronic arm exoskeleton, which is designed so that it could be used to train new soldiers to reach shooting proficiency faster. Baechle has had a childhood fascination with robotics and exoskeletons since he first saw Caterpillar's Power Loader full-body exoskeleton from the film "Aliens."

The near-future vision for the developmental test system is that it would be a training device to help new recruits with novice marksmanship skills and generally help increase combat arms shooting performance on the battlefield.

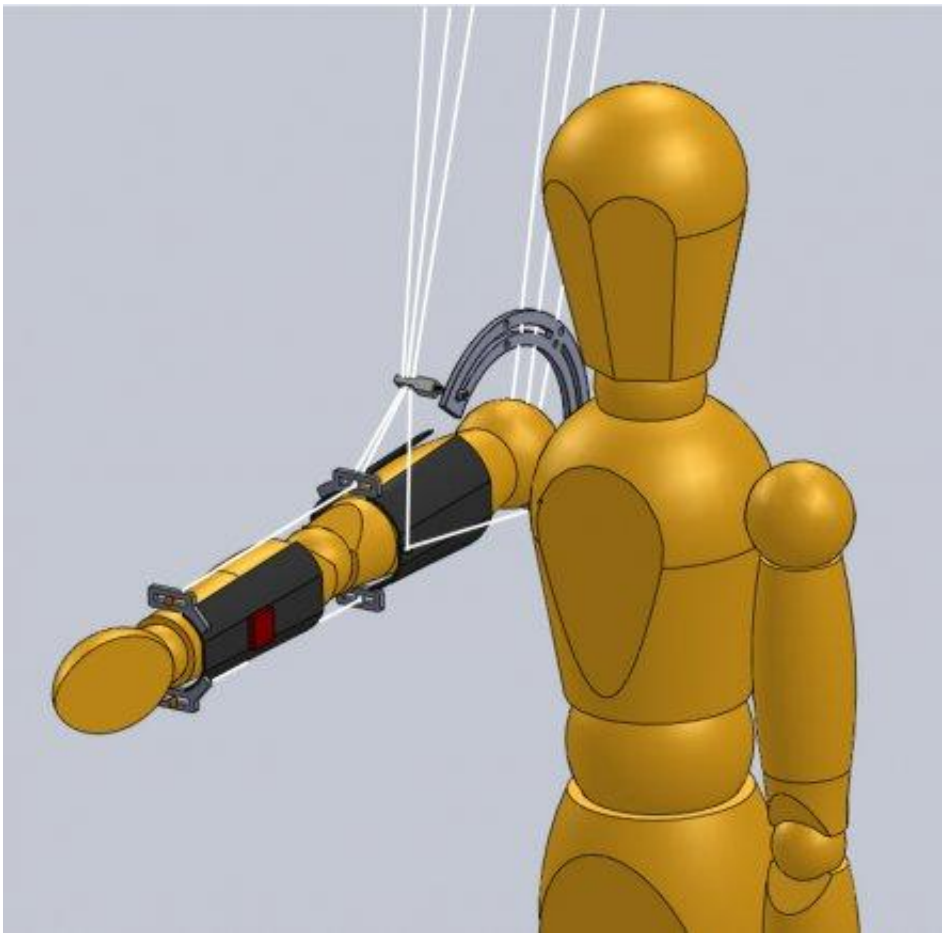
"Soldiers need to be able to aim and shoot accurately and quickly in the chaos of the battlefield," Baechle said. "Training with MAXFAS could improve Soldiers' accuracy, and reduce current time and ammunition requirements in basic training."

The problem he wants to correct is the same as the familiar effect, which happens when someone aims a laser pointer at arm's length toward a board on the other side of the room, and notices a slight, but constant movement of the laser light on the board. The initial experiments showed that after subjects wore MAXFAS and then performed a shooting trial, the tremor that causes this type of shake was lessened, even after removing the device, he said.

Baechle is on a team that specializes in using lightweight materials to enhance the performance of soldiers and their equipment, said Eric

Wetzel, team leader of the Multifunctional Materials Team at ARL.

"At ARL, we strive to develop new approaches to challenging army problems, and are especially attracted to high-risk projects that could drastically improve soldier capabilities," Wetzel said. "Dan's work demonstrates that the integration of advanced materials, robotics, and control algorithms can help address a critical army requirement—shooting proficiency—in an unconventional way."



Computer-simulated modeling of the MAXFAS cables, which attach from behind to enable the red sensor to feel and adjust the slightest of arm movement, help the team communicate to human sciences experts the concept of how they would like to improve shooting proficiency. Credit: Doug LaFon

MAXFAS is modeled from a robotic device to train arm motions of stroke victims at the University of Delaware. Baechle wanted to make the design functional for marksmanship and used carbon fiber to make the exoskeleton lighter. He envisioned a device that would stabilize its user's arm during the shooting cycle, either on-the-spot or to train for long-term proficiency, he said.

"The soldier is already wearing a lot of weight on missions. I figure with a carbon fiber exoskeleton, I could add a big performance benefit without much additional weight," Baechle said.

Baechle mounted motors for the MAXFAS cable-driven arm behind the wearer, which pull the cables that are attached to arm braces, as a puppeteer would. The braces are made from carbon fiber, and add very little weight to the arm. Sensors on the braces feel the involuntary tremor in the arm and send signals to the motors to correct it, but do not restrict voluntary motion, he said.

His idea is a crossover between materials and human sciences. As he looks forward to refine his initial proof-of-concept results, Baechle said he plans to bring together experts in both fields, as well as young scientists.

Sean Averill, a research assistant from Drexel University who is working with Baechle for six months of real-world experience, assists on the MAXFAS technology with tasks like getting motion streaming into the lab view, wiring and designing the systems security latch.

"I get an end goal to accomplish and the freedom to design it," Averill said.

Researchers use high-speed motion sensor OptiTrack cameras mounted around the test area to monitor the mechatronic arm exoskeleton's effect on simulated shooting. Credit: Doug LaFon

MAXFAS has passed its first test, showing potential to correct arm tremors in the laboratory.

"You could have the greatest proof of concept, but what is important is demonstrating the value of the device to those with army mission requirements," Baechle said.

Baechle believes the project he has been working on for the last year has

a chance, because fatigue, involuntary tremors in the arm and difficult situations like shooting under fire or shooting on the move will continue to degrade shooting performance in soldiers even as more advanced weapons technology emerges.

"My vision is that one day, a more mature version of MAXFAS could be used to improve aim on the battlefield despite any adverse conditions," he said.

What the ARL team has produced in the laboratory hasn't quite caught up with the science fiction exoskeletons we see in movies like "Iron Man," but, Baechle said, "In science, we are making great progress toward making science fiction a reality."

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