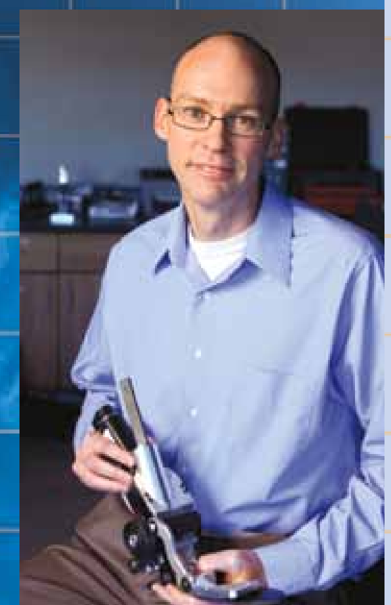
THE BIONIC PROF

By Stephen Filmanowicz

Dr. Phil Voglewede is on the frontier of artificial limb development.



In the 1970s, the TV hit *The Six-Million Dollar Man* hooked viewers on the idea that "bionic" body parts could make an injured astronaut as strong, fast and eagle-eyed as a superhero.

Thirty-five years later, Dr. Phil Voglewede, an assistant professor of mechanical engineering at Marquette, and an interdisciplinary group of colleagues are on the cutting edge of creating real-world bionic body parts, specifically, a powered prosthetic ankle and foot. No, there are no 60-miles-per-hour sprints or dump truck dead lifts in Voglewede's federally funded lab, but there is progress on something ultimately more impressive — a prosthesis that comes close to matching the remarkable performance of the real thing.

Voglewede first started wondering about better options for lower-limb amputees during the early years of the current Iraq War. But he couldn't fully fathom the scope of the challenge he was wading into. For all the forces it absorbs and transmits, the human ankle is supremely lightweight and efficient. It's also controlled in nuanced ways to bring the right combination of force and rapidity to the task, whether it's running, climbing steps or navigating uneven terrain.

Complicating the challenge are the pros and cons of today's common prostheses, straightforward passive devices that fix the foot and ankle at a 90-degree angle and provide some propulsion after flexing slightly under the user's weight (a bit like a spatula springing back to form after being depressed). "On a level surface, their performance is not too bad," observes Voglewede. "People that use them exert more energy than they would normally have to. They walk at a slower pace." Often crafted of carbon fiber, they tend to be lightweight and relatively affordable.

By incorporating a motor, coiled spring and improved joint mechanism, Voglewede and his team learned — theoretically at least — that they could design an ankle that closely matched the thrust, timing and range of motion of an actual ankle. They also learned that each of those elements would add weight and bulk to their design — deal-breakers if not managed carefully. "Those are very common engineering tradeoffs," he says. "I want more power, but adding more power adds more mass [and bulk]. So how do you balance those factors?"

At one point, Voglewede's team had a working model that tested well in terms of force and motion but was scaled more for Bigfoot than a human. With its bulky steel motor and transmission, it topped the scales at 10 pounds and had screws designed for mounting to a bench, not attaching to a residual limb. With help from a $390,000 grant from the National Institutes of Health in 2009, the team started refining its ideas into a new prototype that could be tested on actual amputees.

Voglewede and his graduate students have since made exhilarating progress. The newest prototype has a compact motor and more human-scaled proportions. It's about half as heavy as its predecessor. Soon to be equipped with sensors that will detect heel lift and cue the release of force for the push forward, the model is due for testing on three amputees in May 2011. And coalescing around the device is a growing collaborative team including Dr. David Del Toro — an associate professor of physical medicine and rehabilitation at the Medical College of Wisconsin who has shared clinical knowledge and will recruit test subjects — and Marquette mechanical engineering professor Dr. Joseph Schimmels, a specialist in spring design who is pursuing potential breakthrough ideas that could yield the power of a motorized ankle using only springs to harness and redirect energy normally generated as part of the walking process.

Although important tests and years of revisions lie ahead, Voglewede says his bionic ankle has already been an eye-opener. "We are engineers. We typically deal with more structured environments, like industrial settings," he says. "Having to deal with the variability of humans and variability of amputations has been a huge lesson for us and something we'll take to all of our future projects."