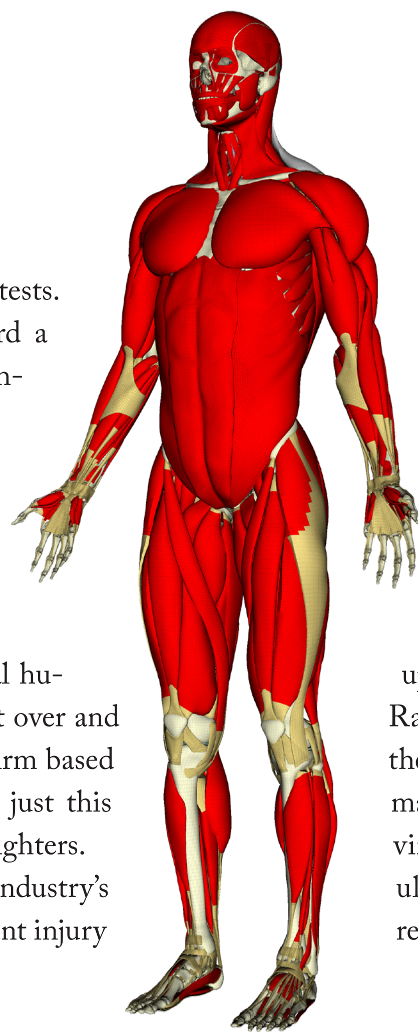
EVOLUTION OF A CAVEMAN

Corvid Technologies creates a virtual human to predict injuries from IEDs



We've all seen the safety tests. A new car speeds toward a cement wall, and a crash-test dummy takes slow motion punishment as the hood crumples and the windshield shatters. It's always an uncomfortable, wince-inducing moment, not to mention expensive for the principals involved. But what if you could do that test with a virtual human body instead of a doll? And do it over and over again. A high-tech engineering firm based in North Carolina has accomplished just this feat—in response to the need of Warfighters.

The Hybrid III, the automobile industry's standard crash-test dummy for occupant injury prediction (developed in the 1970s and improved on since) has also been used by the military. When it comes to soft tissue injuries to the lower body, however—a main concern in IED underbody blast scenarios—the Hybrid III falls short.

In 2016, Corvid Technologies of Mooresville, North Carolina, stepped up to help protect Warfighters by using a Rapid Innovation Fund (RIF) contract from the U.S. Navy Marine Corps System Command (MCSC). Their goal? To complete a virtual human body model that could simulate injury from any force acting on it. The results of this contract became Corvid's

Computational Anthropomorphic Virtual Experiment Man, or CAVEMAN.

CAVEMAN is a convenient acronym for Corvid's model, but the sophistication of the technology could not be further from its Neanderthal namesake. Corvid's lead researcher Kevin Lister explained that while other companies had created virtual models of the body for injury assessment, none of them had CAVEMAN's level of detail and ability to model soft tissue damage. "The goal was to create a tool that really mimics the human body," he said.

Corvid came to human body modeling through Small Business Innovation Research (SBIR) contracts awarded in 2013-14. Empowered by the SBIR program, the company developed Battle Damage Assessment Visualizer (BDAV) software, which offers quick access to a database of hundreds of simulated IED scenarios that can be used to assess damage risk to a vehicle from under-body blasts.

Allen Shirley, Corvid program director, said that work led the company to consider modeling to predict specific injuries to the lower body. In 2013, the company decided to provide internal funding for research in this area and brought Lister, a grad-student engineer specializing in surgical simulation, into the fold to lead the effort.

Lister wasn't sure a project like CAVEMAN could succeed, but he and the rest of the team set about creating a model. They started with solid computer-aided design models of body parts and developed a finite element (FE) model of the human body.

Finite element analysis is an engineering method which breaks large problems into a subset of elements utilizing mathematical equations to investigate the stresses and strains induced on a structure due to external loading (force exerted on it). In the case of virtual human body modeling, each element is then "put back" into the whole body for a model that, after incorporating the material properties, simulates how each part of the body will react to a particular loading scenario.

"The DoD saw the utility of it and was willing to invest early on," Naumann said. "Corvid engineered the geometry and solution methodology. Now they have something that is just an incredible tool."

Three years and thousands of simulations later, Corvid was close to its goal. But more funding was needed. The RIF award allowed the team to complete the model and conduct tests on its injury prediction capabilities.

Corvid engineers used more than 4.5 million elements to create CAVEMAN. The model consists of the complete skeleton, 397 muscles, 342 ligaments, 16 organs, and skin. Velodyne, a sophisticated computer program that solves all of the mathematical equations across all of the elements utilizing hundreds to thousands of computer processors to simulate outcomes from given inputs, can then be used to simulate an under-body blast event, or other force acting on the body, to predict injury.

"We started with the lower body and worked our way up—comparing lower leg impact tests in the CAVEMAN model to lower legs in the cadaveric studies," Lister said. "When we started seeing we were able to predict injury in cadaveric studies—that's when I actually believed that we could do it for the whole body."

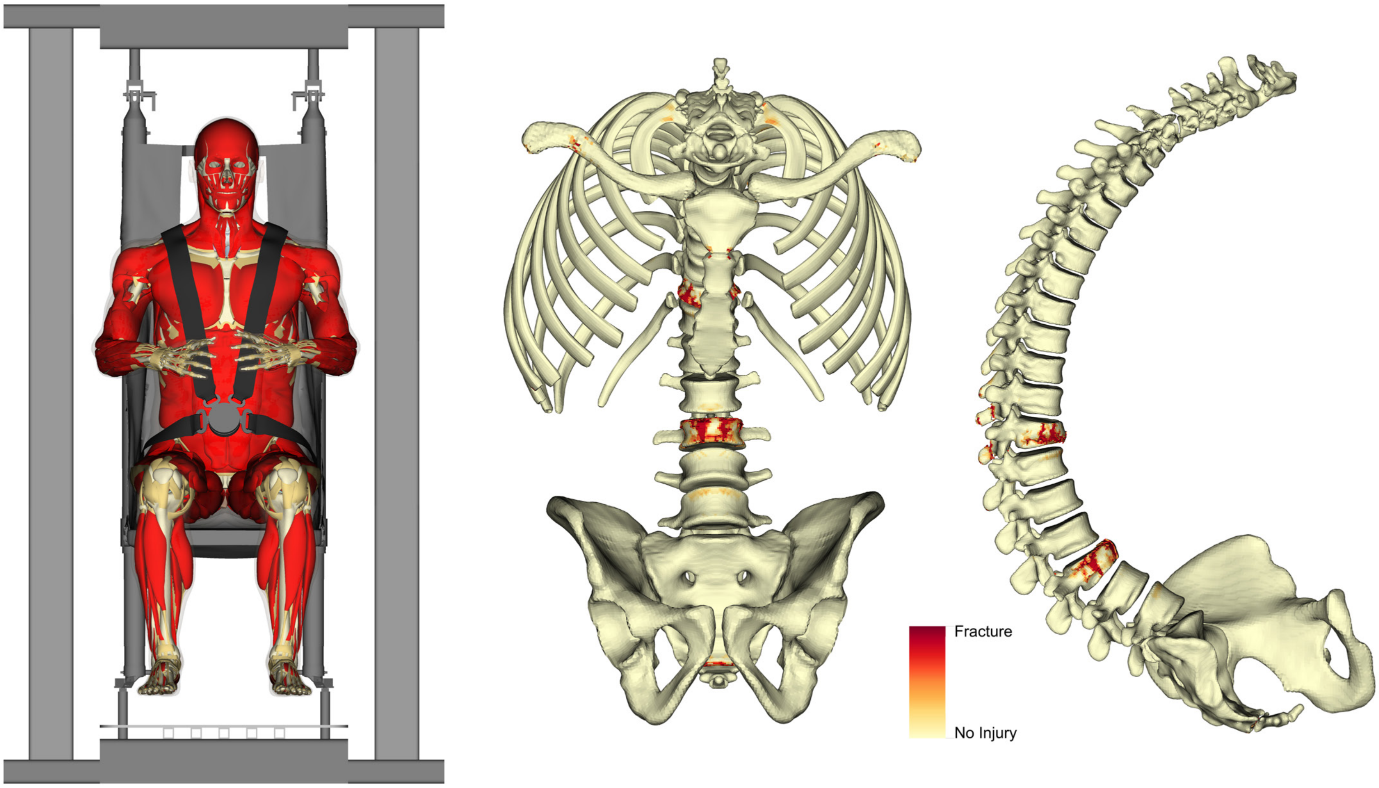
"The Rapid Innovation Fund did exactly what it was intended to do," Shirley said. "The investment came at the right time. The level of detail we could afford to put in the model was really aided by the RIF funding."


Allen Shirley


Kevin Lister

Corvid's work could have huge implications for injury prediction and advance protection for a wide span of human

Photos courtesy Corvid Technologies, Inc.



The CAVEMAN technology from Corvid Technologies, Inc., incorporates more than 4.5 million discrete elements to provide predictive injury assessment for warfighters and civilians alike.

body functions, according to Eric Nauman, professor of mechanical engineering and director of Purdue University's Human Injury Research and Regenerative Technologies Laboratory. Researchers at Purdue are using the CAVEMAN model to simulate impacts and resulting brain injuries in athletes. Using MRI scans, they can "connect" an individual's head to CAVEMAN and produce patient-specific models of the skull, white matter, gray matter, ventricles, blood vessels, and fluid spaces. The models can then be used to investigate each individual patient's head loading response to determine what impact his or her brain, skull, and neck can endure before the damage cannot be naturally repaired by the body.

Nauman noted that the potential to assess individual athletes for brain injury to assure that adequate protective equipment is used could be a huge contribution to the civilian world. And he believes that the potential for use of CAVEMAN in the future could extend to cardiovascular analysis, drug delivery, and the study of cancer.

Nauman said early on he and other researchers looked at what Corvid was doing with CAVEMAN as a "moonshot kind of project." He noted how important the SBIRs and RIF were in the development. "The DoD saw the utility of it and was willing to invest early on," he said. "Corvid engineered the geometry and solution methodology. Now they have something that is just an incredible tool.

"The CAVEMAN model gives us a foundation not only to protect all our soldiers better, but it's also going to lead to clinical tools that will allow us to design therapies," he said.

Modernization Priorities: Biotechnology and General Warfighting Requirements (GWR)
RIF Award: 2015 Navy USMC: "Computational Anthropomorphic Virtual Experiment Man (CAVEMAN) Model for Injury Assessment in Kinetic Events" (M67854-16-C-6581)
National Defense Strategy Pillar: Force Readiness and Lethality