 By Joan Lynch, Managing Editor

SOPHISTICATED MATHEMATICAL MODELS OF HUMAN PHYSIOLOGY AND MULTIPLE ENGINEERING DISCIPLINES UNITE TO BRING A HUMAN-PATIENT SIMULATOR TO LIFE. MEET STAN.

SAVING STAN

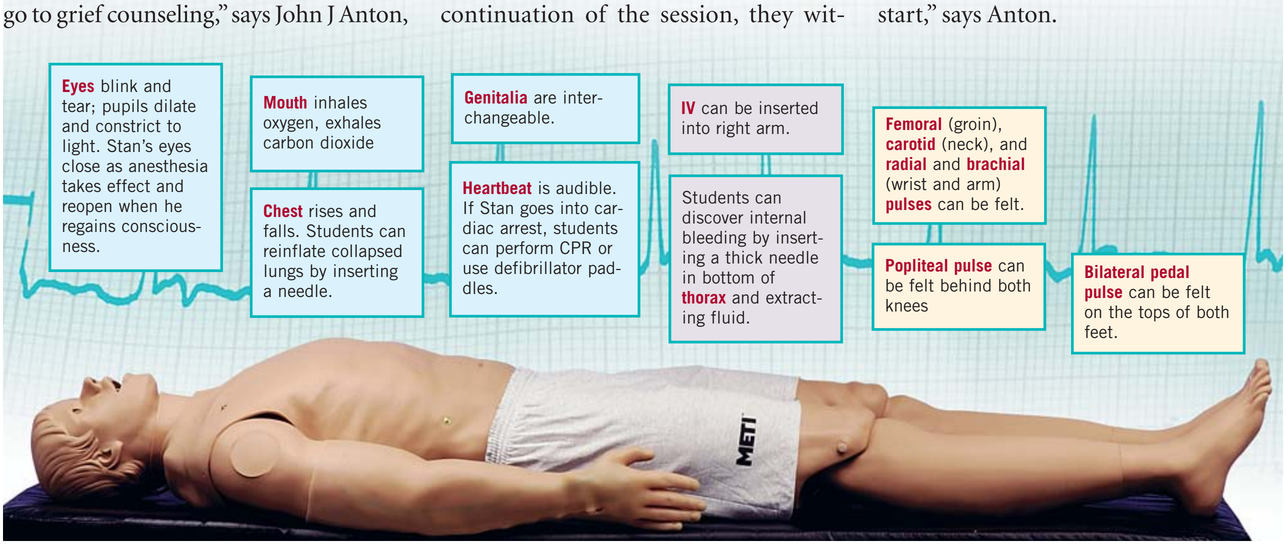
Cadavers are often a medical student's first patients. As valuable as they are in teaching lessons on the complexity of human anatomy, they hold one unavoidable drawback: Cadavers are hardly interactive. The first time most interns see shock, hypoxia, or an overdose is on a live patient in extremis—too late to discover that the would-be doctor gets flustered or forgetful under stress.

Enter Stan, short for Standard Man, an adult-sized, interactive, computer-controlled automaton. Stan can flutter his eyes, breathe, vomit, have a heart attack, and stroke out. In short, Stan can simulate and mimic countless human diseases and conditions. It's a convincing performance. "The effects are very real. In one of our nursing-education programs, Stan died. A young nurse actually had to go to grief counseling," says John J Anton, vice president of engineering and government systems/chief technology officer of METI (Medical Education Technologies Inc) in Sarasota, FL.

So, one inadvertent benefit to Stan might be in helping certain students realize they're on the wrong career path. But his power is saving lives through interactive, scenario-based, hands-on training. And it works. After students at a medical school in Washington, DC, finished a demonstration on cardiac arrest and CPR, they went to the cafeteria for a meal. Like some shockingly preordained continuation of the session, they witnessed a man having a heart attack. "They saved the man," says Anton, and they credited their recent training on Stan.

THE REAL DEAL

HPS (human-patient simulation) has come a long way, from the days of the less-than-lifelike Resusci Anne mannequins to the current models of simulators such as Stan D Ardman, which METI developed at its Florida facility (see below). To achieve the lifelike results, METI has successfully integrated all engineering disciplines—electrical, mechanical, materials, human factors, and software—with a sophisticated educational curriculum and virtual-reality computer-based training. "But it's physiological modelers that really drive us. The Coca-Cola formula, if you will, is mathematical differential calculations for human physiology. That's where we start," says Anton.



(Courtesy METI)

Simulating the operation of the heart, lungs, and nervous system from mathematical equations is daunting, as is finding engineers with the necessary skills. Take, for instance, the ideal candidate for a METI physiologic model developer, who must have a degree in applied mathematics or electrical or biomedical engineering; knowledge of human physiology; experience with mathematical modeling of human physiology and pharmacology; proficiency in the use of simulation-development packages, such as Matlab, Mathcad, Mathematica, or Maple; and experience programming in Java and C++.

To create a realistic scenario for the medical mannequin, these engineers "start with the mathematical equations that reflect the cardiovascular and respiratory systems. Then, we do an equation for a drug, which we validate in medical literature. The drug will affect [Stan's] respiratory and cardiovascular system, as it would in a human being. The equations are coded in C++ and positioned as code to be instantiated into our software. Our software is Unix-based," says Anton.

In a real-world training scenario, students see Stan lying on a gurney or hospital bed, "hooked up to real-world equipment—real ventilation machines, real anesthesia machines, real defibrillators. That is its strength," says Anton. Three computers run the show. "The controlling computer and executive agent is the G4. There's a Linux computer inside the rack, and there's a homegrown computer that drives the simulator." With the HIDEP (HPS Internal Data Exchange Protocol), users can also write software to allow external devices and computers to communicate with Stan.

And, even before an instructor gets down to work, METI preloads data for about 35 "patients" onboard the instructor's G4 Mac. For instance, using the Patient Editor, an integrated component of the main application software, Stan can emulate a healthy 25-year-old male with no outward signs of a debilitating condition. Or Stan can become a 62-year-old truck driver, who smokes a couple of packs a day and drinks heavily. Interchangeable genitalia allow Stan to turn into a pregnant Stanette, a first-time mother-to-be at age 45.

The instructor can modify the preconfigured patient profiles through the use of tabs, drop-down menus, and parameter settings to test the knowledge of the hospital staff. And he can control the patient's cardiovascular, neurological, pulmonary, and metabolic responses via the main computer or a handheld wireless device. During the next year, according to Anton, METI engineers will rebuild the software so that the user interface will be "platform-agnostic; that is to say, you can use anything you want: PDA, tablet, Blackberry, PC, or Mac."

After deciding on the patient parameters, the instructor uses the next piece of the sophisticated software, the menu-driven Scenario Editor, to view and modify more than 70 scripted patient settings, such as cardiac arrest or blunt-force trauma. He can then customize and piggyback common medical problems, such as high blood pressure, with more critical events, such as collapsed lungs. As an added benefit, the teacher can make on-the-fly changes to the script while the simulation session is in progress, so students learn to adapt to unexpected situations in medical emergencies.

Stan's simulations can be astonishingly subtle and complex. Imagine that Stan is an otherwise-healthy male who has diabetes. Using the Pharmacology Editor, the instructor can modify the effects of dosages of insulin on the cardiovascular, respiratory, and neuromuscular systems. Graphical displays illustrate the profile of drugs delivered to the patient.

HOW IT WORKS

As for Stan himself? "The mannequin is an electronic, pneumatic, hydraulic, mechanical device," says Anton. "We use all of those different disciplines to create realistic effects. For example, take the pulses." In a training scenario, students can feel the five bilateral locations—pedal (foot); popliteal (behind the knee); femoral (groin); radial and brachial (wrist and arm); and carotid (neck). Beneath Stan's skin is a maze of electrical and hydraulic lines and actuators. "We also have a genital/urinary system, which is mechanically driven by gravity."

For the skin of the mannequin, METI began by researching vinyl and plastic, which were unsuitable for the application. Under development now is a skin-like material that's based on technology used in the auto-racing industry for self-sealing tires. "Rather than replace patches of skin that wear out like we do now, you can puncture this material 600 times before you have to [replace it]," says Anton.

METI R&D efforts concentrate on making the mannequin's internal anatomy as realistic as possible. "We pioneered the replication of the human airway. Most of them were sculpted," says Anton. Instead, METI engineers took CT scans and used the Solidworks 3-D program to model an anatomically correct airway that prepares students for delicate procedures, such as intubation.

Prick Stan, and he bleeds, enthusiastically at times. At a demonstration for the military, METI engineers performed a traumatic amputation below the knee, complete with severe arterial bleeding. "It was so realistic, people turned away. We shot blood 20 feet across the room," according to Anton, and onto the uniforms of the surgeons general of the US Army, Navy, and Air Force, who were in attendance.

METI and the military have been partners since 1997, working with the Special Operations community on classified business. More recently, simulators have been deployed to Iraq and Afghanistan, where there's no question that combat medics who've trained on the simulators have saved lives. "We've heard that directly from the military," says Anton. And long before September 11, METI simulation technology has been instrumental in emergency and disaster preparedness around the United States.

METI also recently reprogrammed Stan for space travel. To train the next generation of astronauts to deal with medical emergencies in zero gravity, Stan has lifted off on NASA's KC-135 aircraft, which simulates the condition by performing a series of parabolas.

STEERING CLEAR OF OBSOLESCENCE

In its continued quest to introduce newer and better simulators—the list encompasses adult, pediatric, and canine versions—the company has just finished rebuilding its electronics. The high-end version of Stan, which costs approximately $200,000, employed 11 boards; the new design brings it down to one. The ECS version, a lower priced model used for emergency-care training, employed a PC-104 stack and two cards and now uses a single board. But overcoming obsolescence remains a constant challenge.

"We did the design work for the new board and outsourced the board itself. RS-232 ports had changed and been updated, and, when we got the board back and plugged it in, it didn't work...We started to troubleshoot it with our failure-investigation team. It could have been anything with the complexity of the system. It took us two weeks. It ended up being a driver," says Anton.

Stan himself will never have to worry about becoming obsolete; METI often hears of intriguing new uses for the mannequin. One nursing-education program intubates Stan, hooks him up to various machines, and uses makeup to give him a near-death appearance. The educator then prepares the staff to compassionately manage grieving family members when the decision has been made to remove life-support systems. And METI has found success with a model that simulates symptoms of emphysema and narcotic abuse to promote smoking-cessation and antidrug programs in high schools.

And best of all? Anton uses Stan to not only teach life-saving procedures, but also to motivate the future ranks of engineering professionals. "When kids ask me, 'Why should I take math?' or 'Why should I take chemistry?' or 'Why should I take physics?'" he points to Stan. "The answer is, 'You can do cool stuff like this.'"□

BUILDING BLOCKS

Lou Oberndorf in 1996 founded METI (Medical Education Technologies Inc), headquartered in Sarasota, FL., and in 1997 recruited John J Anton, who had worked at Loral with Oberndorf and some of the founders. Anton is now vice president of engineering and government systems/chief technology officer at METI. He has watched the company grow from five to about 125 employees and has seen revenue skyrocket, as well. "We're privately owned, we're debt-free, and we're profitable."

Which is not surprising. More than 1000 simulators are in use at all branches of the US military, NASA, hospitals, universities, and medical schools in every continent, and a line of technologically advanced learning modules and education programs supports the teaching efforts. In addition to employing medical advisors, sales staff, and marketing professionals, METI hires designers and engineers from every discipline with one goal in mind, according to Anton: "We're trying to build the kind of company we always wanted to work for."

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