A technician is shown assembling a prototype airway trainer

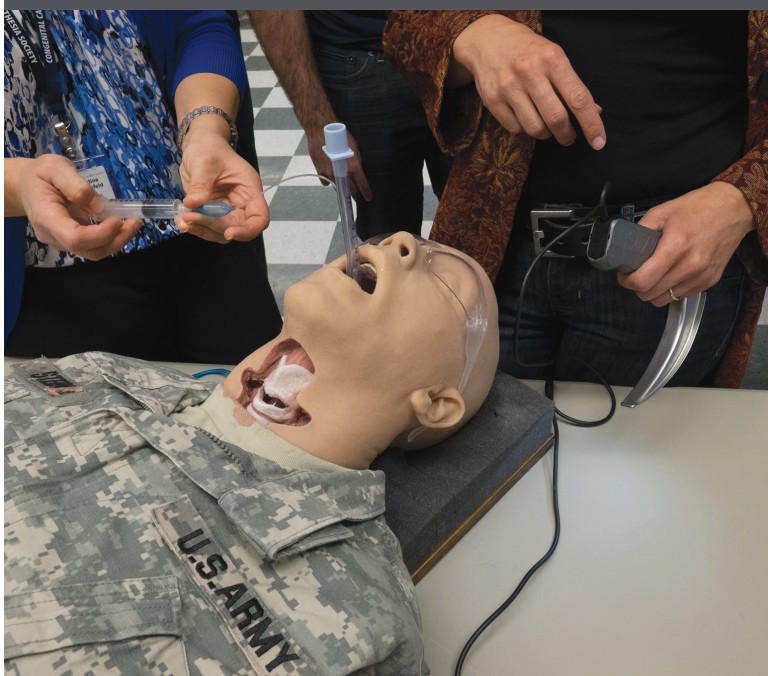
# Breathing New Life

## 3D Printed Manikins Improve Emergency Medical Personnel Training

Life-saving airway procedures, such as inserting a tracheal tube, are critical skills for both battlefield and civilian medical personnel. Learning these skills and keeping them honed requires hours of practice on airway trainers that closely resemble human anatomy both in their geometry and physical properties.

“The initial reaction from the Army was that this is the most realistic trainer they have ever seen.”

Jack Stubbs
**associate program director,**
**University of Minnesota Medical School**

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Case Study

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However, obtaining the best training is difficult to achieve. Accessible yet accurate training models remain too rare to properly train all necessary personnel in this medical procedure. Now the University of Minnesota Medical School, in a study funded by the U.S. Army Research Laboratory office in Orlando, is developing a much more realistic airway trainer with the help of 3D printing.

## Complexities of Airway Training

Finding the best training mechanisms for airway procedures is harder than it may sound. Live humans are not a good airway training option thanks to our gag reflex. Cadavers are difficult to obtain and their physiological properties are actually quite different from live humans. So first responders and medical students train on special manikins with internal passages modeled after human anatomy.

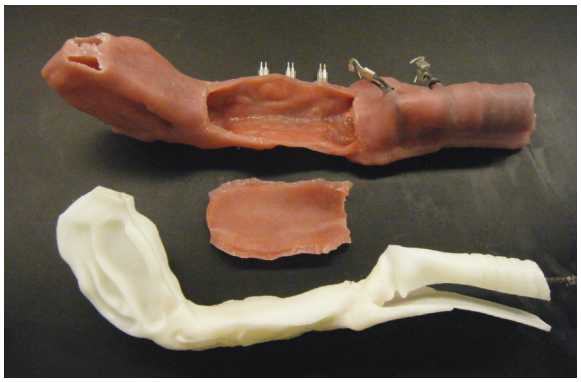
The problem is that most manikins do not accurately represent the human anatomy either in their geometry or physical properties. This means that in many cases, emergency medical personnel are receiving inadequate training.

For example, a study in the June 2012 issue of the journal Anesthesiology noted that “the airway anatomy of four high-fidelity patient simulators and two airway trainers does not reflect the upper airway anatomy of actual patients.” The article states that these inaccuracies could have a substantial negative impact on airway training and also on device studies that are conducted with airway trainers.

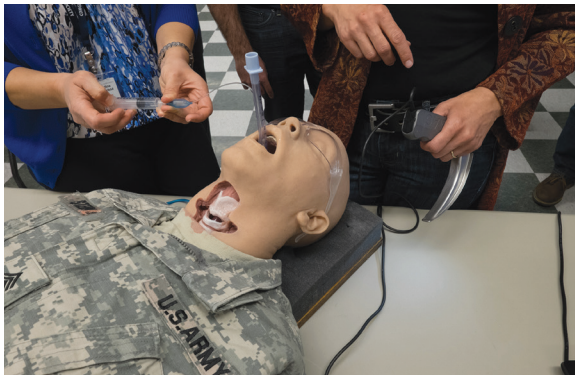
## Building New Models

Researchers at the University of Minnesota Medical School are working to overcome these obstacles. After obtaining images of magnetic resonance imaging (MRI) and computed tomography scans of human airways, they used Vitrea visualization software to segment the tissues and airspace in the scans. The researchers then used Mimics and Maya imaging software to refine the designs and generate STL files.

Human geometry taken from MRI and CT scans provided the starting point for 3D printing.



3D printed components were used in a prototype airway trainer




Prototype created by the University of Minnesota more accurately replicates human physiology.

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The university used a Fortus 250mc™ 3D Printer to build models of the skeletal system such as the skull and jaws. Researchers then created molds by pouring silicone rubber over the pattern. After the molds cured, they used them to produce soft tissue models. The university also used an Objet350 Connex3™ 3D Printer to print a much more realistic version of the cervical spine than is used on current airway trainers. They chose the Objet350 Connex3 3D Printer for its ability to print multiple materials in a single model to simulate the complex mix of range of motion and restriction of motion found in the cervical spine.

The University of Minnesota built four prototypes and provided them to the Army for evaluation. The 3D printed prototypes accurately reproduced live human geometry and used materials that closely simulate the properties of human tissues. “The initial reaction from the Army was that this is the most realistic trainer they have ever seen,” said Jack Stubbs, associate program director at the University of Minnesota Medical School. “They told me that if it was available it would be the only trainer they would use.”

## Future Work

The Army staff is currently working with the prototypes and will soon provide more detailed feedback. Then the university will build additional prototypes. The university is also developing a production process which will also rely heavily on 3D printing. The university plans on implementing this process to build trainers in production  after approval by the Army.

The rollout of this new procedure could prove invaluable for military personnel too. When a soldier suffers a battlefield injury that blocks his or her airway, there are only seconds to restore their breathing – sometimes while being transported to a hospital.

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