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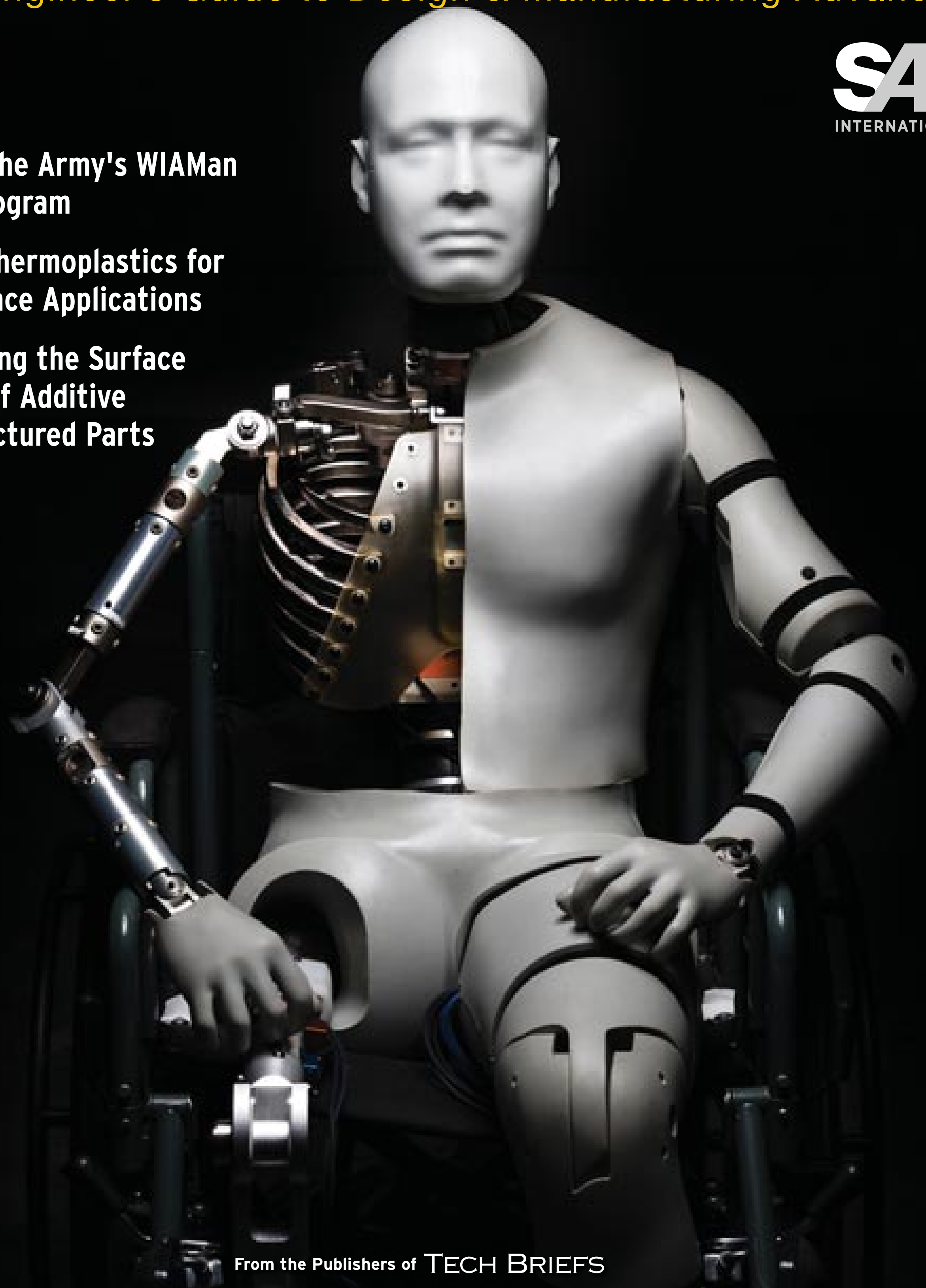


Inside the Army's WIAMan Test Program

Using Thermoplastics for Aerospace Applications

Improving the Surface Finish of Additive Manufactured Parts

From the Publishers of TECH BRIEFS

WIAMan

High-Tech Test Lab Focuses on Saving Soldiers' Lives

The newest crash test dummy in development is actually a blast test dummy. WIAMan (Warrior Injury Assessment Manikin) is a ground-breaking anthropomorphic test device (ATD) being developed by the U.S. Army. It's the first test dummy designed specifically for vertical loading in under-body blast (UBB) scenarios, like the ones soldiers may experience in combat from IEDs. A key goal of the program is to develop a scientifically-valid injury criteria for blast testing of military ground vehicles. This test data will be the most advanced of its kind and will be used to develop new, safer vehicles and associated equipment to help reduce injury risk for warfighters. Another first coming out of this program is the high-tech data acquisition system that is entirely contained within the dummy, making it the first completely autonomous device of its kind.

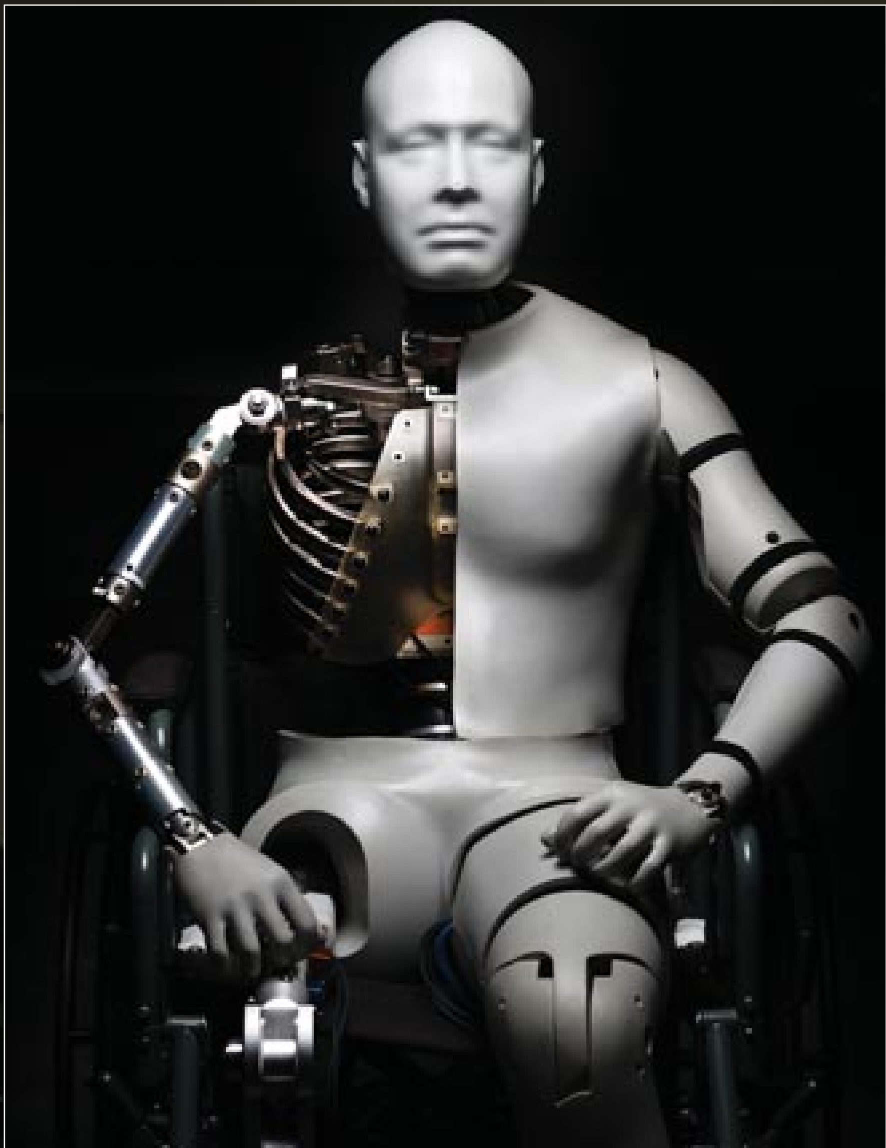
WIAMan is a strategically orchestrated collaboration of government, academia and industry. The prime contractor to build both the manikin and the data acquisition system, and integrate them, is California-based Diversified Technical Systems. Known for its expertise in biomechanics and automotive crash safety testing, DTS manufactures miniature data recorders and sensors for test labs around the world. Since the project started in February 2015, two generations of prototypes called Technical Demonstrators have endured a grueling series of lab tests and blast event 'ride-alongs' in the field.

"Ultimately, WIAMan testing seeks to answer two life or death questions when a military vehicle is attacked in an IED blast," says Tamer Abubakr, Research Engineer at DTS. "First, did the soldiers survive the blast? Second, can everyone still fight and get themselves out of there to safety? So, the better the vehicle is designed to withstand blasts, the better the chance of the soldier's survival."

Once the final production units are delivered next year, the Army will be using WIAMan in live fire tests as much as 2-3 times per week. But first WIAMan has to pass an extensive battery of tests. During the past year, WIAMan underwent 90 full body drop tests along with a battery of laboratory tests to measure its response to blast force, acceleration and rotational velocity. Throughout that time, virtually every component from the fasteners to the flesh were continually monitored for biofidelity, performance and any improvements that may help with manufacturability. Getting just the right material composition, including the same center of gravity (CG) is critical. Even the foot is a very specific ratio of molded pieces of different densities with an underlying metal structure to provide the same compression rates of a human foot. Unlike traditional crash test dummies, the WIAMan development path has pioneered the use of new materials and innovative manufacturing techniques such as 3D printing of production parts. The ingenuity of the team has paid off not only in terms of accelerating an already aggressive build schedule, but in performance as well.

While WIAMan is a ground-up new design, it is loosely based on the Hybrid III 50th percentile male frontal automotive crash test dummy that's been modernized to represent today's soldier. If WIAMan could stand upright, he would be 5'10" tall and 185 pounds (84 kg), which is an inch taller and 13 more pounds of muscle than the Hybrid III.

"After these 90 full body drops, the dummy looks like it did the day it rolled off the showroom floor," says Abubakr. "It hasn't been damaged at all. That's a huge improvement for the Army that's constantly replacing parts on the old Hybrid III dummy that was designed nearly 40 years ago. WIAMan doesn't have those issues because it was designed to handle that type of vertical load."



Technical Demonstrators are currently undergoing test and evaluation by the U.S. Army. The high-tech manikin supports up to 146 channels of data acquisition inside the dummy to measure force, acceleration and rotational velocity that a soldier may experience in a vehicle blast.

The WIAMan Test Lab

In spring of 2017, a new 3,000+ sq. ft. lab located inside DTS headquarters in Seal Beach, California, was built exclusively to support the multi-year project. The climate-controlled WIAMan Lab is furnished with state-of-the-art test equipment that includes a drop tower, a linear impactor and high-speed cameras.

Key to the test lab is a Lansmont 122 Shock Test System, which is an 11-foot drop tower used to replicate the vertical impact in a vehicle blast. The drop tower consists of a cast aluminum plate that replicates high shock pulses like those soldiers may encounter in combat. There's also an electric hoist lift and positioning system that enables precision repeatability, an element that is key to any validation testing. One of the major features designed in WIAMan is the capability to support up to 146 channels of embedded data acquisition designed to measure potential skeletal injuries. The ultra-small data acquisition systems are distributed throughout the test manikin and connected to a variety of sensors. With all the wiring and cables inside, not only is the system better protected, it also eliminates 146 cables exiting the dummy, which can cause issues simply trying to position a dummy in a vehicle and can alter test dynamics if a cable gets tangled or damaged.

The same 5-point harness that's in a MRAP (Mine-Resistant Ambush Protected U.S. military vehicle) secures WIAMan in the drop tower seat while a 200g pulse simulates both the amplitude and frequency characteristics of blast shock. Underneath the drop tower there are four landing pads with bumpers made of various materials that can be adjusted to vary the pulse waves. Load cells in the drop test seat measure multiple load paths through the pelvis and femur to quantify potential spine and lower extremity injuries. The data collected includes force, moments, acceleration and angular velocity from sensors located in the pelvis, spine, tibia, foot and heel.

"When running a drop test, we focus on velocity and the 'time to peak'," says Abubakr. "If the dummy is brought to a certain height and dropped free fall, it's going to reach a specific velocity at the time of impact. That's how the velocity is tuned. The time to peak is how quickly it de-accelerates from that peak velocity. The bumpers are adjusted and changed out during different tests to tune the 'time to peak' and make sure it's similar enough to a live blast that we can compare it."

WIAMan, the first test dummy built specifically for under-body blast testing, is prepped on the drop tower for a validation test that will impart a 200 g pulse for 7 milliseconds, simulating an under vehicle blast.

Linear Impactor Testing

Long ago Aristotle understood that "the whole is greater than the sum of its parts." Using a Cadex Linear Impact Testing Machine SB202, the team has been able to effectively perform iterative testing on a single component like the pelvis to see how it may perform or affect the entire dummy after even small modifications are made.

Testing a variation of the WIAMan leg on the linear impact tester helps evaluate how design and engineering changes may affect the overall performance.

Multiple high speed cameras in the lab capture test images at 100,000 fps which allows the engineering team to track and map data with the movements on camera.

"The purpose of the linear impactor is to be able to mount up just the leg or just the pelvis and obtain similar input to the whole body test," says Abubakr. "By testing individual segments we can make design changes and quickly test it. For example, if a material was changed on the foot, how does that affect the response? If we're happy with the results, we can move it to the whole body test and get that same response."

Each part is instrumented with sensors to monitor linear and angular accelerations, axis forces and bending moments. The linear impactor accelerates a 20kg impact mass to a velocity of 20 meters/sec using a pressurized air tank that's connected to a pneumatic actuator. An air-brake stops the impact, while a dual-beam light gate measures the final velocity.

High-Speed Cameras

In addition to all the injury data being collected inside the dummy, multiple high-speed cameras capture all the action outside. Analyzing gross motor movement in slow motion helps engineers better understand the forces soldiers experience in the field. To do this, the lab is equipped with multiple high-speed cameras to capture the action at over 100,000 frames/second. The Photron FASTCAM Mini AX200 has a Gigabit Ethernet Interface for high-speed data transfer and the ability to remotely switch off cooling fans to eliminate any vibration when recording at high magnifications.

"If we see anything strange in the test data we can go back to the high-speed camera and help determine what it is," says Abubakr. "We also put markers at different joints and on the rest of the dummy body, then we can track those points as they move in space and compare it to the human response we're trying to replicate."

That 'human response' is based on extensive biomechanics and cadaveric research done in partnership with top universities throughout the country. Each university focused on key injury areas primarily in the lower extremities like the spine, pelvis and feet to create predictable under-body blast UBB patterns. The data has also allowed the team to develop a Finite Element Model, an extensive software-based injury library and validated analysis techniques.

In June 2017 DTS will be delivering four Gen One WIAMans so the Army can do final testing and approve everything before WIAMan goes into production next year. "An automotive vehicle crash takes place in 30-40 milliseconds, whereas a military vehicle blast is over in just 5 milliseconds," says Abubakr. So far, at every stage, WIAMan has successfully proven its ability to perform and consistently deliver data that has only the smallest window and literally one chance to get it right.

The test data WIAMan is responsible for has far reaching, life-saving implications not only in the development of safer military vehicles, but to families around the world. "Saving lives is the big motivation for this project and really all of DTS. We're out there helping people and saving lives and making vehicles safer, whether it's military or automotive," sums up Abubakr.

This article was written by Randy Boss, Program Manager, Diversified Technical Systems (DTS) (Seal Beach, CA). For more information, visit ***http://info.hotims.com/65858-501***.