

SIMULATION: THE (ALMOST)



REAL THING

Military simulation facilities have come a long way from even a few years ago. Many now are sophisticated enough to mimic real-life operations. Some are absolutely eye-popping. And they've become standard fixtures in the military.

By Art Pine

Not that long ago, training simulators didn't draw many gee-whizzes in the American military. Sure, they were useful tools, helpful in training aviators, tank commanders, and ship-drivers. And they had come a long way from the primitive joy-sticks hooked to cathode-ray-tube monitors that had begun to appear in the early 1980s.

But they also had serious limitations. Many still depended on using actual equipment—a real airplane or tank cockpit, or a re-creation of a ship's bridge—that was costly to put together. The computers they used were sluggish, and the software was primitive, with only middling resolution, not all that realistic. And they provided relatively few options for varying the training scenarios.

Over the past five years, however, military simulators have made some impressive leaps. On-screen icons have been replaced by high-resolution images that show precisely what you'd see through the window of your airplane, tank, or Humvee—with such fidelity, realism, and speed that you'd think you were actually on scene. Besides the graphics, the simulators produce realistic sounds and vibrations, and put pressure on your body just like a live flight or sortie would. Some even emit smoke or odors. It's easy to become airsick.

And unlike training that uses actual aircraft or vehicles, instructors can cram enough scenarios into simulators that students can get more varied experience in a few days than they'd encounter during weeks of live-

action training. Today's pilots "can actually do things in their simulators that they cannot do in their airplanes," says Marine Corps General James N. Mattis, commander of the U.S. Joint Forces Command.

TECHNOLOGICAL TAKEOFF

It's not just aircraft, tanks, and ships anymore. The technology has spread to training for everything from maintenance and repair of Humvee engines to how to assemble an automatic rifle—much of it on a laptop computer—to high-level war games. "We now have technology that wasn't available even two years ago," says J. L. Larry Morton, a systems engineer with DEI Services Corporation, a simulator manufacturer.

Among the examples:

- Computer networking lets instructors link simulators around the country, enabling pilots, tank commanders, and ship-drivers to take part in joint exercises in which their platforms seem to be operating in concert—flying or driving side by side with those of the other participants, all in the same sortie and aiming at the same targets.
- Out-the-window views for aviation simulators offer such high resolution, fidelity, and exquisite detail that pilots say they're almost indistinguishable from what they see when they're actually flying over the same territory. The fidelity is so good that commercial pilots now are permitted to use simulators to qualify for certification in different airplanes from those they normally fly.



U.S. NAVY (S. A. THORNBLOOM)

BATTLE STATIONS TRAINING The fabricated USS *Trayer* (BST-21) is a smaller replica of an actual ship that simulates shipboard emergencies at Recruit Training Command Great Lakes. Here, Secretary of the Navy Ray Mabus (right) tours a bomb-damaged berthing compartment on 16 July. Included, according to the author, is "the smell of salt spray."

- A Navy simulator called Battle Stations 21 employs electronics to enhance a two-thirds-scale replica of an actual ship to train recruits how to handle lines, respond to damage-control problems, tend to mass casualties, and conduct man-overboard drills and other exercises. The simulator provides an uncanny feeling of reality, complete with the smell of salt-spray when the user enters the building.



GROUND-BASED FLIGHT SIMULATORS On 14 April, Secretary of Defense Robert Gates took a turn in a flight simulator at Warrior Hall Flight School XXI Simulation Complex at Hanchey Army Airfield in Alabama. Future simulators will not only provide training, they will attach physiological sensors to the trainees to determine how they react.

“It expands the ability to suspend disbelief,” says Cathy Matthews, head of the systems engineering division at the Naval Air Warfare Center in Orlando, Florida. “You really feel like you’re training on an actual ship.”

- A prototype system now being refined at the Orlando center takes six key physiological measures of trainee pilots and correlates them with the aviator’s performance to determine how realistic an experience his or her simulator program is providing. Designers hope to use it to help reduce pilots’ stress—both in simulators and in the air—by “rerouting” critical information to a different part of the brain to avoid overloading it.

The complex device can accept between eight and 256 electrodes, attached to a flexible cap, that track a pilot’s brain waves, respiration, heart rate, perspiration, pupil size, and eye movements during an entire course of simulated or actual flight movements. “This sort of thing is the future—not only of simulation, but of operations,” says Navy Lieutenant Philip Fatolitis, a Ph.D. psychologist working on the program.

- Even simulators designed to teach military personnel how to maintain their equipment are going higher-tech. Six months ago, developers began working with a prototype system designed to eliminate the expensive “electronic gloves” now used to allow trainees to control the

three-dimensional images that show them how to disassemble or remove and replace parts.

Using the new technology, the simulator can identify a trainee’s own hand movements and voice commands. When a trainee turns a screwdriver or takes out a part—or tells the simulator that he or she is doing so—the graphics will immediately go to the next step, or review the previous procedure if the trainee has performed it incorrectly.

HOW WE GOT HERE

Behind such dramatic changes has been a series of developments that transformed simulation well beyond what many warfighters imagined possible. Hardware technology has improved dramatically in the past few years, producing high-performance computers that provide far greater capacity and speed and yet are much smaller and less expensive—paving the way for ever more sophisticated software.

Exploiting these advances, software designers have come up with vast improvements, both in the

quality of graphics and in interactive capability that has created whole new opportunities for using simulators. They offer trainees and instructors large numbers of options, from varying tactical and threat situations to weather changes and simulated malfunctions.

Perhaps the most visible turning-point came in 2004, when the military turned to designers of teenagers’ computer games to help harness the realism and imaginative scenarios of Nintendo and its successors to military training. That catapulted military simulators to a level of sophistication more useful than ever to training commands in all the armed services.

“The new simulators were comparable to the videogames that the very same Soldiers were playing at home,” says Peter Singer, a Brookings Institution simulation expert and author of *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (Penguin, 2009).

Among the civilian enterprises to which military planners turned were Disney World and the companies that supply it. They thus made extensive use of state-of-the-art gaming technology. The location was one of the reasons simulator systems units of all four armed services are located in Orlando. The annual Interservice/Industry Training, Simulation and Education Conference is held there each December as well.

Military planners also helped finance the Institute of Creative Technologies, a gaming-focused research center at

the University of Southern California that uses techniques employed by the computer-games industry to devise new kinds of simulators. Both USC and the University of Central Florida, which works on simulator technology, too, are close to large numbers of commercial gaming-software firms.

Indeed, military simulator centers now buy much of their hardware off the shelf from commercial suppliers. And they often adapt software programs being sold by the gaming industry for military use, employing the graphics techniques and interactive features to create scenarios tailored to training needs. It's a lot cheaper than trying to design their own from scratch, military technology experts say.

Also spurring the expansion of simulators was the end of the Cold War. Before the fall of the Berlin Wall, warfighters could focus their training on air battles against Soviet-built MiGs, tank battles in Western Europe, or large-scale naval battles—all with relative confidence that any actual combat would involve a limited number of scenarios. Now they must face an array of skirmishes in a wider variety of locations.

"Nowadays you have to train, and you have to train even more than you ever did before," says the Naval Air Warfare Center's Cathy Matthews.

Combined with the dramatic drop in prices of sophisticated computer equipment, the use of simulators by the military has exploded over the past five years. "The biggest change is that it's gone from being unique to being ubiquitous," says Mark R. Sinclair, a staff vice president for aviation joint solutions at General Dynamics' information technology division in Virginia Beach, Virginia. "It's everywhere now."

The 1990-91 Persian Gulf War gave the public its first glimpse of "what the gee-whiz was all about" in the use of computers and software on the battlefield, recalls Susan Maybaumwisniewski, a retired Navy captain and simulator veteran now at Business Executives for National Security in Washington. Weapons such as the Tomahawk, laser-guided missiles, and smart-bombs wowed the public and members of Congress.

WHY SIMULATORS PAY

It's easy to see the benefits of simulators. To start, they're a lot less expensive than trying to train warfighters solely in real aircraft, tanks, or ships. Using an actual

airplane to provide flight training requires buying more aircraft, setting up flight schedules, fueling and maintaining the airplane, and risking an accident that could injure the pilot and damage or destroy the plane.

There are other big differences. In actual flight-training, the student spends time getting to the flight line, taking off, flying to the training area, and getting back. You can't just program in changes in the weather or threat situation; sometimes it takes weeks, or months, before you experience them. And dogfights require the use of several aircraft simultaneously.

By contrast, training in a simulator requires only that the student climb into the pilot's seat and get started. The equipment is far cheaper, there's no need to travel to an airfield, and the instructor can easily change the training scenario by overlaying changes in weather, visibility, the type of enemy aircraft, and their position and threat to the student's plane. And the training exercises require fewer instructors for each student.

At the same time, students can train for combined operations without having to call up actual aircraft, mechanized vehicles, or artillery. In newer models, they can work with students in other services or at other locations to simulate joint or combined operations. They can repeat a scenario as many times as they'd like, use it to rehearse



'UNIQUE TO UBIQUITOUS' What was once a novelty is now very much a reality for troops preparing to deal with mishaps and attacks. Here, Sailors assigned to Combined Task Force Individual Augmentee receive training at Camp Buering, Kuwait on 24 October. They are learning survival techniques in mine-resistant ambush-protected egress.

specific operations, and replay what they've done for an after-action review.

Those who train first in simulators typically get more out of their training on a real platform, says William Swartout, technology director of USC's Institute for Creative Technologies. "The live experience is much more valuable for them," he asserts.

Best of all, pilots, tank commanders, or ship-drivers can practice responding to a malfunction without risking a crash. “Live training is still a dangerous endeavor,” says Roger Smith, chief technology officer of the Army’s Program Executive Office for Simulation, Training, and Instrumentation. “In real life, you have an accident and flip your vehicle over. Planes crash.”

Rear Admiral Gary Jones, who recently retired as commander of the Naval Education and Training Command, estimates that providing flight training in a real F/A-18 Hornet jet fighter costs about \$10,000 an hour—far more than a simulator’s hourly price-tag.

Moreover, military officers say the increasing sophistication of simulators over the years has changed the way the services train—and fight. Commander William Ipock, head of training and standardization at the office of the Chief of Naval Air Training Command, or CNATRA, says the fact that both training and tactics have become far more complex is partly the result of advances in simulators. Besides training warfighters, simulators are used to provide a reality check for tactical and logistical plans and to rehearse for military operations and prepare after-action analyses.

Finally, simulators are easier on the environment than actual aircraft, tanks or ships. Not only do they save substantially on fuel consumption, but they don’t spew smoke, parts, or other debris over the waters or the countryside.



IMMERSED IN WORK Because live training is decidedly more dangerous, the Aviation Survival Training Center in Jacksonville, Florida, teaches students on 4 June how to egress safely from the 9D6B Modular Egress Training System in a simulated helicopter crash. Such training is not only safer, it’s cheaper, too.

Simulators also are proving to be a breakthrough in the treatment of post-traumatic stress disorder. They can provide returning warfighters with enough realistic sights, sounds, smells, and action to trigger the kind of recall that PTSD sufferers often need to let their own memories break out so they can begin to recover. A program called Virtual

Iraq now is being used in 40 clinics across the country, with a high success rate.

“It enables you to experience the same trauma, but in a safe environment,” says Brookings’ Singer.

WHAT THEY DON’T DO—YET

But there also are some shortcomings. Even the most advanced simulators can’t yet duplicate the stress or the fatigue from the fog of war that aviators experience when they’re actually flying in a real aircraft, for example. “The real world has millions of variables, much more than the simulators do, and it’s more stressful than a simulator because you’re aware that whatever you’re handling could crash,” the Army’s Roger Smith says.

“It’s never as good as the real thing,” says General Dynamics’ Sinclair. “Nothing can replace the stress, the uncertainty, the gut-wrenching knowledge that if I screw up, real people will die.” But, he insists, today’s simulators “can come close.”

For many tasks, such as basic flight training, instructors simply don’t need state-of-the-art simulators, says CNATRA’s Ipock. “A lot of people mistakenly think that the military always has the cutting edge of everything, but nothing could be further from the truth,” he says. “What we’re looking for is not so much cutting-edge, but what will get the job done for the best value.”

One gaping hole is the dearth of simulators designed to help train foot-Soldiers. As General Mattis pointed out in an address to technology experts in mid-October, simulator designers have made amazing leaps and bounds in improving training devices for aviators, tankers, and ship-drivers. But the designers offer little for infantry troops, even though they historically suffer 86 percent of U.S. combat casualties.

True, Marine Corps and Army commands use computer simulation to train infantry for urban warfare—by using images of Iraqi homes and families in mock houses at urban-warfare training centers—but the images still lack the kind of reality and the wide range of scenario options that aircraft and tank trainers provide. Compared to simulators for aviation and mechanized warfare warfighters, they aren’t very interactive.

“Today what we need are virtual Sadr Cities, virtual Ramadis, virtual Fallujahs,” General Mattis said, to provide ground troops with the kind of training they need to cope with the threats they face in Iraq and Afghanistan. “All of JFCOM is going to be very supportive of this effort.”

USC’s Swartout pins the gap on the limits of technology. “It’s a lot easier to build a simulator for an aircraft,” he says. “We understand aerodynamics and can simulate it.” But creating simulators for foot-Soldiers involves mak-

ing computers and software packs that are small enough for troops to carry around and making human responses more realistic.

Swartout envisions higher-fidelity graphics and software programs that will make virtual village elders and others who appear in ground-troops' simulators able to understand what a soldier says, recognize his tone of voice and body language, and engage in a two-way conversation that effectively makes the virtual humans "behave like real people."

"That's a few years away," he concedes. "But the encouraging thing is that this is a problem that's recognized, and it's going to get a lot of attention. Recent experiences in Afghanistan and Iraq have shown us that these skills have become very important."

THE NEXT GENERATION

Industry and military program specialists say the next generation of simulators may be as big a leap from today's as the current models are over those of five or ten years ago.

Tomorrow's simulators—some of them already in the testing phase—will offer increased fidelity and three-dimensional images, greater mobility and miniaturization, and software that uses the Internet for warfighters to update programs and graphics to reflect changes in equipment or the tactical situation. They also will permit even more interoperability for different platforms and in different locations.

There also will be a big push to enhance simulators for the foot-Soldier. Randall Hill Jr., head of USC's Institute for Creative Technologies, describes a plan for an infantry simulator with a head-mounted display that provides a different view—and changes in the virtual threat—each time a Soldier turns around or approaches an actual wall in the darkened training building.

"What we're looking for is ways to trick people into thinking they're walking straight while they're physically turning" to avoid bumping into a wall in the training building, Hill says. Moreover, he adds, the simulator equipment would have to fit into a Soldier's backpack and not weigh any more than the actual combat gear it would displace for the training exercise.

The next generation of simulators also is likely to provide wider opportunities for commanders at all levels to simulate operations in an urban environment, helping them to determine priorities, look at hotspots, and see how their tactics are playing out, technologists say. If things calm down in one part of the virtual city—or, alternatively, the situation worsens—they'll get to practice responding to it.



U.S. NAVY (S. WEVERS)

INTO THE FUTURE These U.S. Naval Academy midshipmen Dolphin Club members seem spellbound by the sophisticated *Los Angeles*-class submarine simulator on 6 November at the Naval Submarine School in Groton, Connecticut. According to the author, "the next generation of simulators will be just as eye-popping as those of the past five years."

And designers will seek to imbue simulators of all kinds with behavioral modeling, which enables a simulator to mimic the behavior of virtual adversaries and trainees to interact more realistically in various situations, whether they involve computer-generated Afghan warlords or crowds of people in a marketplace. That means programming the simulators' software with hundreds of possible responses to almost anything the trainee does.

Also a potential breakthrough is the Naval Air Warfare Center's prototype physiological measuring system, which is being developed in conjunction with the University of Iowa and being tested both on simulators and on live flights. Not only will it eventually lead to even more realistic simulators, proponents say, but it also could change the way aircraft information systems are designed.

Mark Adducchio, chief engineer for the simulators group at Wright-Patterson Air Force Base in Dayton, Ohio, predicts that advances in the next generation of simulators will be just as eye-popping as those of the past five years—including computers and software that can deal with much more information and far greater levels of activity than today's simulators.

"The capability just continues to evolve," he says. So does the quality of training. And so will the value of relying on simulators for more training, predicts CNATRA's Commander Ipock. "Looking ahead at rising costs and shrinking budgets," simulators will become more attractive, he says. "It's expensive to fly the new F-22s and F-35s. From a quick, casual glance, if you can get a simulator with the kind of fidelity you need, there'll be a real incentive to use it as much as you can." ❄

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