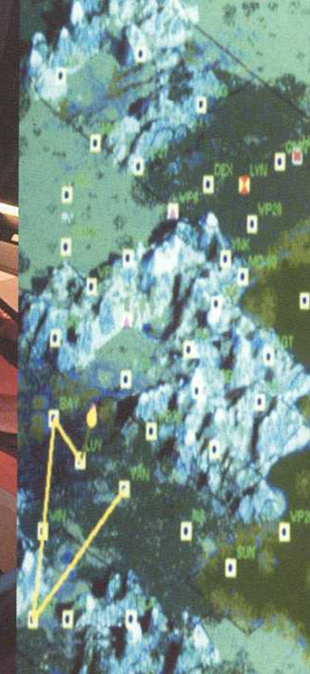
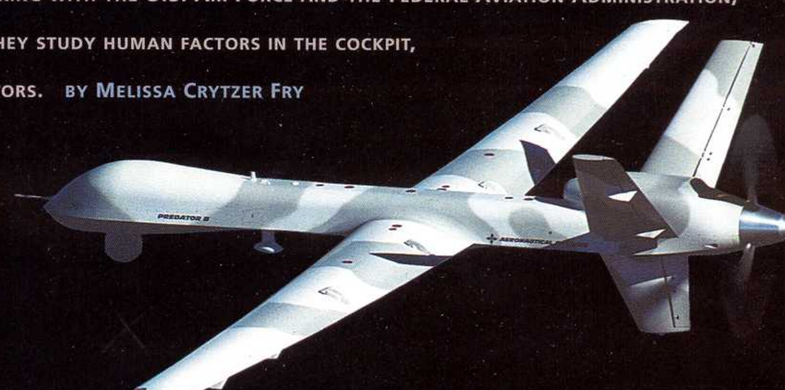


The Human Factor

Members of ASU East's Department of Applied Psychology have had their heads in the clouds lately – metaphorically speaking, of course. The three-person team of Roger Schvaneveldt, Nancy Cooke (above), and Rob Gray is focusing on human factors research – studying how humans behave physically and psychologically in relation to particular environments, products, or services. Working with the U.S. Air Force and the Federal Aviation Administration, the ASU researchers look to the sky as they study human factors in the cockpit, in Predator aircraft, and in flight simulators. By Melissa Crytzer Fry



Model airplane enthusiasts don't think twice about the power that rests in the palm of their hands. On any given weekend, more than a million model flyers across the country happily guide their miniature aircraft into barrel roll turns and square loops. The consequences of a crash are often but a blip on the radar screen. Remote-controlled model planes range in price from $50 to $15,000. They can weigh anywhere from several ounces to 55 pounds. For some, a wrong move means nothing more than scraping up $50 for a replacement or re-attaching a 12-inch propeller. But what happens when the remotely controlled aircraft is life-size, weighs 1,130 pounds, includes a sensor or weapons payload, costs more than $40 million, and is controlled by multiple operators in various locations?

That's just one of the questions a group of Arizona State University researchers is trying to answer. Led by Nancy Cooke, researchers at ASU East's Applied Psychology Program use an environment that simulates the navigational and photographic (payload) tasks involved with the military's super-sized, remote control Predator aircraft. The military refers to these machines as unmanned aerial vehicles (UAVs). Cooke and her colleagues are working to better understand how machines and people work together when physically separated.

"We are trying to understand how groups of people or teams think as an integrated unit," explains Cooke, professor of applied psychology and director of ASU East's Cognitive Engineering Research on Team Tasks (CERTT) laboratory.

There are plenty of questions. How do groups or teams solve problems together? How do they become aware of a situation as a group? How do they share information and make decisions as a unit? What role does stress play in performance?

In the CERTT lab, groups of three work together in a synthetic task environment. The task is to navigate the UAV to a specific position where it takes reconnaissance photos of designated targets. Housed in two separate rooms—one for UAV operators and one for the experimenters who observe—the laboratory is designed to analyze individual and group behavior. Four computer consoles spanning 20 feet run multiple software applications simultaneously over a local network. The computers mirror the responsibilities of actual military UAV operators who control Predator drones.

Each team includes several key players. The Air Vehicle Operator (AVO) controls air speed, heading, and altitude. The Payload Operator (PLO) operates the camera and adjusts shutter speed, focus, aperture, and zoom. The Data Exploitation, Mission Planning, and Command Operator (DEMPC) plans the route from target to target, reporting on location, flight restrictions, and enemy points.

"Individual training usually takes 1.5 hours, then four additional 40-minute missions for team training," Cooke says, explaining the training process for ROTC and other student participants. "The tasks that our subjects complete are simulations of real missions."

With aviation-quality headsets snug, the team members simultaneously review a video monitor and two computer monitors. They also communicate with other team members. The experimenters—about 10 feet away in a separate room—monitor the simulation, interject questions, and change workload in an effort to measure the team's cognition. "We want to learn how best to train people and how to design systems for people to communicate and interact effectively as a group" she adds. Cooke is assisted in her studies by a team of six graduate students, two undergraduates, and a post-doctoral student. "We are attempting to assess and diagnose effective or ineffective performance so we can do something about it."

Such group-reliant tasks in distributed environments—called command and control—are gaining ground across various industries.

"The Predator's UAV task is relevant to military operations and Homeland Security," says Cooke. "The task is also relevant to emergency operation centers all over the place. Staffs at nuclear power plants, hospitals, and airports use similar models that rely on distributed coordination."

Teams are often located in different parts of the world. In many instances they must work together to solve complex tasks that often have life or death consequences. A mis-targeted UAV can cause ground casualties. Improper communication using remote telemedicine can result in a patient's death. A miscommunication between nuclear power plant operators and Homeland Security could be devastating.

RESEARCH RESULTS "We're trying to find patterns that are associated with effective and ineffective team performance," Cooke says. The researchers manipulate many variables such as team workload, team proximity to one-another, and knowledge-sharing during the studies.

At the ASU lab, team members are separated by floor and by partition—in distributed conditions—to determine if performance is affected by eliminating face-to-face communication. "The good news is that it doesn't affect performance to any major extent," Cooke says. "The bad news is that it does affect cognition and behavior. In some environments, that could be critical—a matter of life and death."

The simulations measure a range of responses: Does the team share the appropriate information with the group? Do they benefit by being able to discuss versus not being able to? Do they perform better when they know one another?

CERTT researchers have found that team communications data provides significant performance clues. The ASU scientists worked with Peter Foltz at New Mexico State University. They used a statistical technique called latent

JOHN C. PHILLIPS PHOTOS

Appetite for Flight

Roger Schvaneveldt knows that there is no substitute for firsthand experience. He admits that eight months of flying lessons in the early 1990s and a myriad of solo flights played a key role in his success with recent pilot-related research projects.

"You just don't develop the same understanding with second-hand study," says Schvaneveldt, faculty head for ASU East's Department of Applied Psychology. He has conducted many aviation projects over the past 20 years.

Schvaneveldt's own personal experience learning to fly was the catalyst for a research project that began in 1998. "I asked questions that never would have occurred to me if I hadn't been a pilot," he explains.

The biggest question: how do I keep track of so much information when I'm flying? The search for an answer led to his current project, the creation of a checklist that may someday be used to officially evaluate aircraft displays.

What Schvaneveldt realized when he was learning the ropes was that he accessed certain information only at certain times. He didn't need to know everything at once. For example, knowing distance from the ground was important when he was taking off and landing, but not so important when cruising at altitude. Schvaneveldt became interested in how such priorities change during different phases of flight and how access to information correlated with the pilot's needs.

With the Federal Aviation Administration's (FAA) support, a number of pilots reviewed checklists of information factors that Schvaneveldt created. They were asked to make judgments about how critical each was during a certain phase of flight.

After he compiled the information, the ASU researcher submitted a technical report to the FAA. A few years later, Schvaneveldt was surprised to learn that the report had resurfaced; an FAA employee came across the research findings and agreed that they could be applied to certifying and evaluating new-market aviation information systems. Schvaneveldt then proposed the creation

"Anything that enhances the performance of pilots and aircraft enhances the safety and, hopefully, the enjoyment of the passenger," says ASU psychologist Roger Schvaneveldt

PILOTS REQUIRE INFORMATION ABOUT MANY FACTORS TO PERFORM SAFE FLIGHT: AIRCRAFT PERFORMANCE BASICS, SUCH AS SPEED AND ATTITUDE; GEOGRAPICAL INFORMATION ABOUT COURSE, HEADING, ALTITUDE; MECHANICAL CONDITIONS, SUCH AS FUEL CONSUMPTION; THE OPERATIONAL ENVIRONMENT, SUCH AS THE LOCATION OF OTHER AIRCRAFT AND WEATHER CONDITIONS. A CURRENT COLLISION AVOIDANCE DISPLAY IS SHOWN AT RIGHT.

semantic analysis (LSA) to analyze the UAV team's communication patterns. Researchers use LSA to statistically model the degree to which words semantically overlap. The technique can be used to search for patterns that differentiate successful and unsuccessful teams.

"Using the teams' LSA scores, we can start predicting how effective this team will be based on what they're saying," Cooke explains. However, the problem, she adds, is that the analysis doesn't yet tell us why the team is ineffective—a critical component to improving team performance—and one of the research team's next challenges.

What the research has revealed is that teams with more knowledge about the UAV task—and with more consistent communication patterns—tend to perform better than those without. Most importantly, such research and metrics can be applied to a host of other environments in addition to the UAV task.

THE CERTT LAB OF THE FUTURE While research at ASU East has focused mainly on the UAV command and control environment to date, the CERTT lab can be adapted to support other tasks, with hardware and software modifications. Cooke says the lab could be converted into a NASA Mission Control Center or a hospital emergency room. It also could be used to study team communication in distance learning environments or even the impact of teleconference meetings in the business environment.

"We looked at various incident command centers located in major U.S. airports," Cooke adds. "Those observations revealed that these centers are not ideally designed to handle a broad spectrum of natural, accidental, and directed threats." The ASU researcher thinks that such environments could benefit from research similar to the UAV work.

The potential adaptations for the UAV lab are limitless, but are heavily reliant on funding. "Such modifications are not trivial," Cooke says. "They would require a significant amount of additional funding."

Cooke started her work as a professor at New Mexico State University. She is exploring unique partnerships to ensure that the research continues. The ASU East Applied Psychology Department has teamed up with the Air Force Research Lab and a company called US Positioning Group to form the Cognitive Engineering Research Institute (CERI).

"This is a unique model," says Steve Shope, CEO of US Positioning. "Traditionally, ideas come from the university, and then make their way to industry for commercialization. With this model, industry, government and academia work together as a team in the transfer of technology."

The end result: streamlined collaboration that considers human factors and results in product development in a fraction of the time.

CERI's mission—to continue to solve problems in large command and control environments—is already being realized. US Positioning was recently awarded an Air Force Small Business Innovation Research (SBIR) grant to develop the next generation of command and control for UAVs. If all three phases of funding are provided, the initial award could result in a complete redesign and reorganization of the Air Force Predator UAV's command and control structure.

As Cooke looks to the future, she sees opportunity.

"By understanding how teams work, we can design intervention—technological aids and training programs to help them think as a group." She believes that software—much like the Microsoft paperclip assistant—might be available for immediate feedback in high-risk operational environments. "Wouldn't it be nice to stop a group within a high-risk operational environment from making a critical error?"

THE CERTT LABORATORY IS SUPPORTED BY THE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH AND THE OFFICE OF NAVAL RESEARCH. US POSITIONING DESIGNED, BUILT, AND CURRENTLY MAINTAINS THE LAB.
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of a cockpit certification checklist that would help differentiate effective from ineffective cockpit displays. Similar in design to computer monitors, the displays often contain too much or not enough information to be useful to pilots.

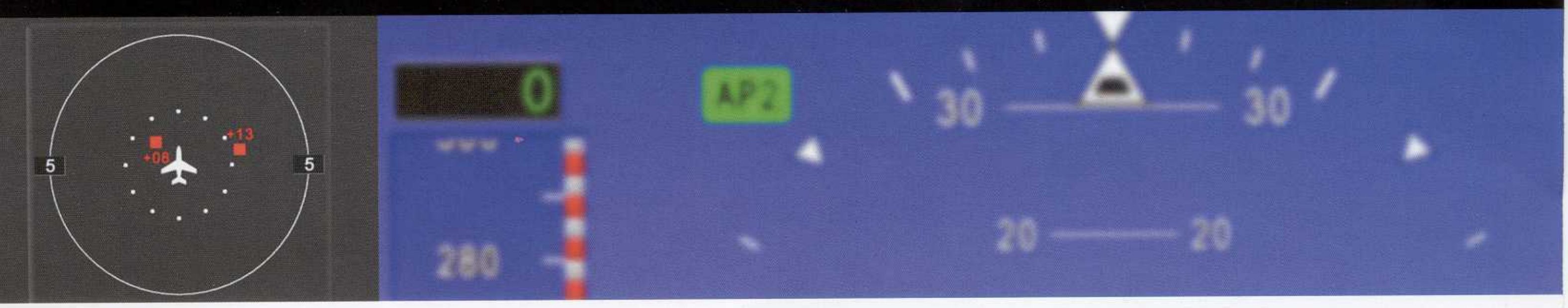
"The checklist can be used to evaluate how well an information display system honors the priority of different kinds of information," he explains. "Is the most important information readily available when you need it? Or is too much information available, making access to important information more difficult?"

The checklist appears as an interactive Excel spreadsheet. It allows users to evaluate availability of information—altitude readings, traffic information, engine system status—during certain phases of flight. It then creates a report that statistically assigns pass, fail, not covered, and clutter designations to each information factor.

Several display devices were evaluated during the initial testing of the checklist. The results revealed varying levels of user-friendliness. Devices that tested poorly illustrated that pilots are often forced to rely heavily on their sense of sight and feel to compensate for poor display information. This is a dangerous situation in poor visibility conditions, according to Schvaneveldt.

In the future, such design faux pas may be evaluated and possibly eliminated due, in part, to what began as the fledgling questions of a beginning pilot. Schvaneveldt thinks it is very likely that future interactive displays will include help screens that contain information relevant only to a particular situation. **Melissa Crytzer Fry**

Schvaneveldt's research on aviation information systems is supported by the Federal Aviation Administration. In his research, he has collaborated with Dennis Beringer (FAA), John Lamonica (Lamonica Aviation), and Tom Leard (Honeywell Aerospace Electronic Systems). For more information, contact Roger Schvaneveldt, Ph.D., Department of Applied Sciences, ASU East, 480.727.1066. Send e-mail to schvan@asu.edu



A Dose of Reality

Video game villains leap across modern television screens and computer monitors with such lifelike realism that it is often difficult to remember that they are animated. In other games, twists and turns around true-to-life race tracks transport players behind the wheels of the cars they're driving. The experience can seem so real that heart rate and car seem to accelerate simultaneously.

But in the world of flight simulation, the task of creating realistic computer-animated backdrops and textures is often more complicated than simply adding a dose of realism to the screen. Flight simulators are an essential training tool for pilots of commercial jets and military aircraft. The machines are used to teach basic flying skills to novices and to test the skills of experienced pilots in emergency situations.

Since 1998, Rob Gray has been studying flight simulator design and the ability of pilots to transfer their simulator training to the air. Gray is an assistant professor of applied psychology at ASU East. What he's discovered is somewhat contrary to the expectations of video game enthusiasts—vivid detail and additional texture doen't necessarily translate to better performance.

During his research, Gray studies the ability of simulator operators to estimate the rate at which they will collide with objects (time-to-collision), and how well they judge altitude. He has learned that performance in these areas is greatly impacted by the types of texture applied to objects on the screen.

Original flight simulators had very little texture. Trees and buildings were represented as single-color, flat triangles or boxes. Early displays didn't even come close to replicating the real flight environment, Gray admits.

But, even today, because the amount of memory required to add texture to a program is immense, flight simulators still lack realism. "Adding a lot of detailed texture to a flight simulator is not only memory-intensive, but it also slows the simulator down, making its response time unrealistic for many training purposes," Gray explains.

Gray used two basic tests to get answers. In one test, he asked subjects to press a button when they feel they are about to collide with an object. In the second test, he allows them to use a joystick to maneuver among hills and objects. Gray found that the addition of texture into flight simulator displays can actually be detrimental in time-to-collision studies.

Gray explains. "In real life, objects get larger and larger as you approach them. The simulator solution has been to 'paint' texture onto objects to make them look realistic. The problem is that, as subjects fly toward a paint-textured object, it doesn't change." The bricks on the building don't get larger. The grass doesn't get greener. One result of such design imperfections is that participants consistently overestimate how much time they have before crashing into an object. "If you're in a flight simulator set up this way, you don't want to make an error like that when you transfer your skills to flying a plane," Gray says.

So, what is the solution?

Additional design and technology improvements, and more research, of course. Gray works alongside pilots and computer designers from the Air Force Laboratory adjacent to the ASU East campus. The work there is focused only on the study of military simulations. "The Air Force Lab uses flight simulators to train pilots and is constantly updating the hardware with new computer simulation programs," says Gray. "They want to find the very best way to evaluate the new technology in terms of human performance."

The ASU scientist thinks that making designers aware of the human performance issues associated with flight simulator design is necessary. The results will go a long way toward creating more realistic flight simulator training programs, where far more is at stake than adding realistic bells and whistles to video games. **Melissa Crytzer Fry**

Gray collaborates with the Air Force Lab to conduct flight simulator testing. Previous studies about time-to-collision were supported by Nissan. For more information, contact Rob Gray, Ph.D., Applied Psychology, ASU East, 480.727.1340. Send e-mail to robgray@asu.edu.