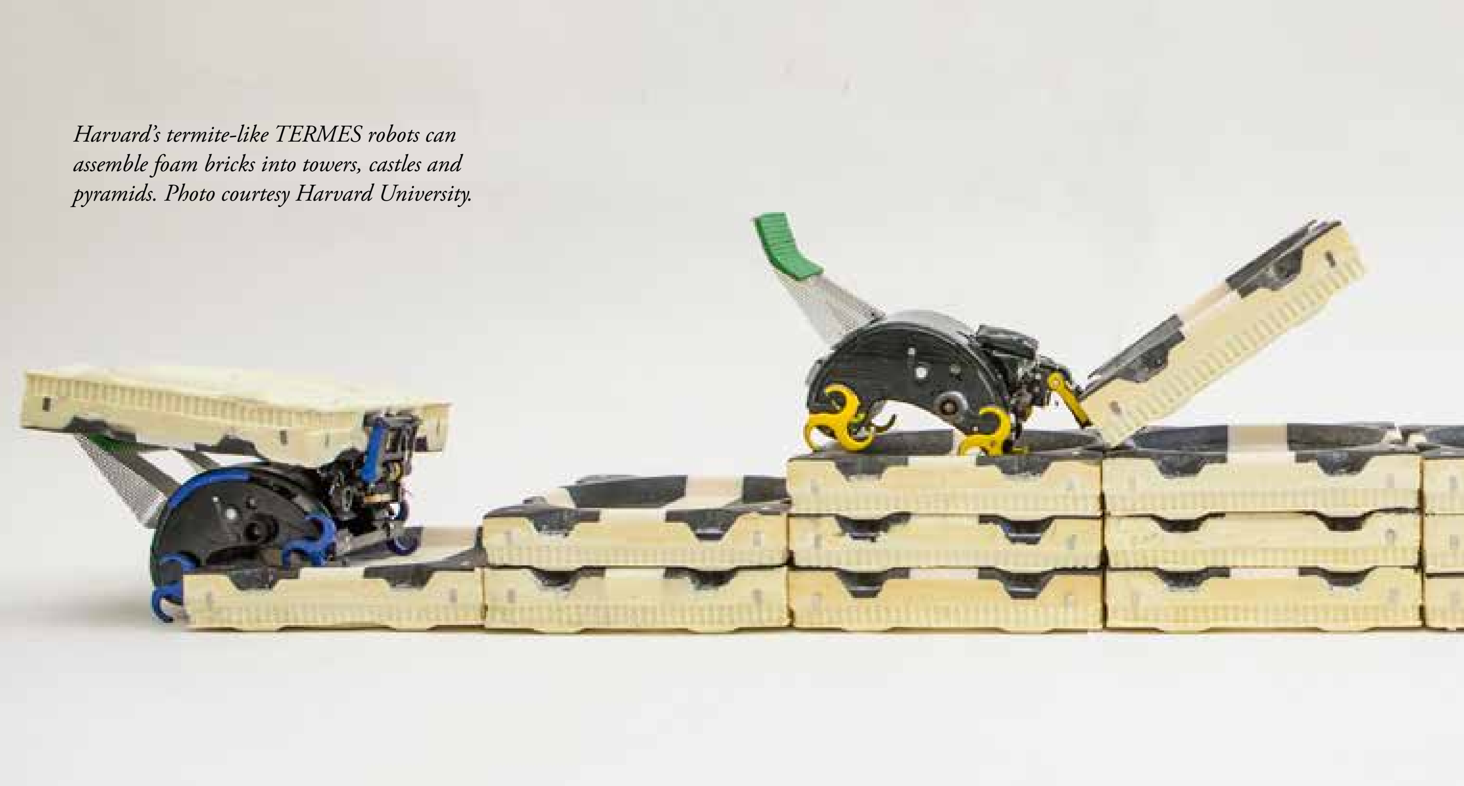

Harvard's termite-like TERMES robots can assemble foam bricks into towers, castles and pyramids. Photo courtesy Harvard University.

STOP, COLLABORATE AND LISTEN

Can Unmanned Systems Cooperate?

By Marc Selinger

As small unmanned systems proliferate on the battlefield and in civilian life, interest is growing in having these devices band together to maximize their effectiveness. Government, industry and academia have a variety of efforts underway to advance such cooperation among unmanned air, land and sea systems.

This spurt of activity has been fueled by many factors, including the advent of small, low-cost systems and sensors and the increasing ability of these devices to perform tasks without direct human intervention. Potential benefits of unmanned collaboration include extending the range of the systems, reducing the time it takes to complete tasks and allowing missions to continue even if some systems become disabled.

"There is growing recognition that there exist mission sets or application areas where quantity is a quality on its own," says Timothy Chung, assistant professor in the Naval Postgraduate School's Department of Systems Engineering. Such missions "can potentially leverage many simpler, cheaper, single-purposed assets to meet or exceed the capabilities offered by employing one or a few more complex, expensive, multimission types of assets."

Possible uses for cooperating systems include overwhelming enemy defenses, providing multiple views of a target, inspecting parts of a bridge that are hard for humans to reach, and spreading humidity, temperature and wind direction sensors over a sprawling farm. For example, in one battlefield scenario involving a swarm of five unmanned aerial vehicles, one UAV could detect a target, a second could track it with a full-motion video camera, a third could jam the target's communications, a fourth could laser-designate the target and a fifth could shoot it.

"You're a commander, and you don't have access to a multi-hundred-million-dollar platform that has [multiple intelligence] sensors, but you have access to smaller, less expensive platforms with different types of detection capabilities," says Robert F. Davis, CEO of Proxy Technologies, which makes multi-aircraft cooperative flight control systems. "So you could dispatch them all as a swarm."

Achieving widespread use of unmanned cooperation will require overcoming a host of technological barriers, including improving communications among systems and between systems and operators, and determining how a single operator can manage a large number of systems.

Cultural barriers also must be addressed. Paul Scharre, a fellow

Navy Tests Swarming Unmanned Boats

Photo courtesy Office of Naval Research.

The Office of Naval Research announced in October that it achieved a "breakthrough" for swarming technology during a demonstration with small unmanned boats.

To prepare for the test, ONR installed sensors and software on existing Navy manned patrol craft to convert them to unmanned surface vehicles. During the demonstration itself, the USVs escorted a "high-value" ship and then encircled a threat-representative vessel to block it from the high-value asset. As many as 13 unmanned boats — five autonomous, eight remote-controlled — participated at one time.

Rear Adm. Matthew Klunder, chief of naval research, told reporters 30 Sept. that the technology could have prevented the October 2000 deadly terrorist attack on the USS Cole, in which a small boat detonated explosives near the destroyer off the coast of Yemen.

"If we had had this capability there on that day, I'm sure we would have saved that ship," Klunder said.

The two-week test occurred in August on the James River in Newport News, Virginia. While countering the "enemy" ship, the USVs activated nonlethal weapons, including flashing lights, blaring loud speakers and high-power microwaves. They did not fire their machine guns, because "we were not planning to destroy the target," Klunder said. "We certainly could have done that if that was needed, but in this case, we just wanted to prove the swarming technology."

The technology, called Control Architecture for Robotic Agent Command and Sensing (CARACaS), allows unmanned boats to plan their routes and sense and avoid each other. A single sailor can oversee the swarm. Klunder believes the technology ultimately could support even more USVs than the demonstration's peak of 13.

"We see the future as certainly enabling 20, maybe even 30, if we needed those," the admiral said.

Manned patrol craft currently protect high-value ships in ports and straits. Having USVs perform that function would allow the Navy to field more boats, take troops out of harm's way and have those people do other tasks, according to ONR. Equipping each boat with CARACaS costs a "few thousand" dollars, which is "crazy affordable," Klunder said.

The Navy is discussing the technology's future. Several issues still need to be ironed out, including how to transport such a large number of USVs to a deployment. But Klunder projected that the technology could become operational within a year.

"This train is moving really fast," he said.

and director for the 20YY Warfare Initiative at the Center for a New American Security, says swarming will require a "paradigm shift within the Department of Defense," which is more accustomed to building large, expensive systems and which has sometimes been slow to embrace unmanned systems. He also says the idea of having one operator control more than one aircraft "makes some people very uneasy" in DOD.

Large Numbers

Proxy Technologies, whose Proteus software allows an operator to control up to 32 UAVs, has demonstrated its product in Air Force, Army and DOD military exercises, with the most recent being a U.S. Special Operations Command experiment in March 2014 at Joint Expeditionary Base Little Creek-Fort Story in Virginia Beach, Virginia. During the USSOCOM event, a Skyraider UAV and a simulated L3 Viking UAV worked together to find and examine targets.

"We're going to continue to fly and demonstrate" the software, Davis says. "We're working with the customer set to get this technology adopted into a program of record."

In the summer of 2014, Proxy submitted a white paper to DOD's Rapid Innovation Fund program that proposes using Proteus to coordinate a fleet of unmanned underwater vehicles. The software would allow the small submarines to share information about their missions and systems with each other. Proxy hopes its submission leads to an August 2015 contract award to conduct a demonstration for the Navy.

The Naval Postgraduate School has conducted tests with

A SkyRaider aircraft prepares for takeoff. Proxy Technologies is using its SkyRaiders to test swarming operations. Photo courtesy Proxy Technologies.

as many as 10 small UAVs flying simultaneously, and it expects "in the very near term" to "significantly break that record," Chung says. In 2015, the school plans to conduct an experiment in which two competing groups of students each fly 50 UAVs over Camp Roberts, a National Guard post in California.

Harvard University, Johns Hopkins University Applied Physics Laboratory and the University of Pennsylvania have also been looking at swarming. For instance, in February 2014, Harvard's Wyss Institute for Biologically Inspired Engineering announced that its termite-inspired, seven-inch-long TERMES robots could "independently but collectively" assemble foam bricks into complex structures, such as towers, castles and pyramids. The construction occurred "without the need for any central command or prescribed roles," Harvard says.

Some seemingly promising activities have failed to materialize, however, serving as a reminder that moving swarms beyond the research stage will not be easy. The Air Force Research Laboratory, for instance, studied the possibility of developing micro UAVs that could operate in swarms. The lab predicted in a video that micro air vehicles will play an important role in future warfare. But an Air Force official told a congressional panel in 2012 that it would not to pursue the concept further. The service concluded that the tiny devices would not support any of the service's "core missions," lab spokesman Daryl Mayer said.

Small Numbers

Not all unmanned cooperation efforts involve large numbers of systems. Mesh radios offered by iRobot Corp. are designed to extend the communications reach of as few as two unmanned ground vehicles.

For instance, a robot operator may direct a pair of UGVs to investigate a suspicious object. When one robot begins to get out of range of the operator, the vehicle's communications can be handed off to another robot that remains in contact with the operator.

The robots can also place standalone radios on the ground to serve as additional nodes in the network. If one node stops working, the other nodes "self-organize" to fill the gap.

The mesh radios can be particularly useful in certain military situations, such as a drainage culvert or tunnel that may be planted with a bomb and in urban settings where line-of-sight communications may be impaired by buildings or interference from other communications, says Tom Phelps, iRobot's director of robotic products for North America.

IRobot tweaked the hardware and software of existing radios to turn them into mesh radios. The mesh radios have been fielded by the U.S. military in Afghanistan, as well as by foreign militaries and North American public safety agencies.

The company is also looking to create more commonality among its controllers. One controller can operate iRobot's 110 FirstLook and 310 SUGV, and the company is working toward having a common controller across its entire product line, including the 510 PackBot and 710 Kobra.

"If a team can control multiple robots from a single controller, it may give the team better situational awareness and better control and may eliminate the potential for miscommunication," Phelps says. ■