Advances in Laser Technology Bring Potent New Capabilities to Small UAS

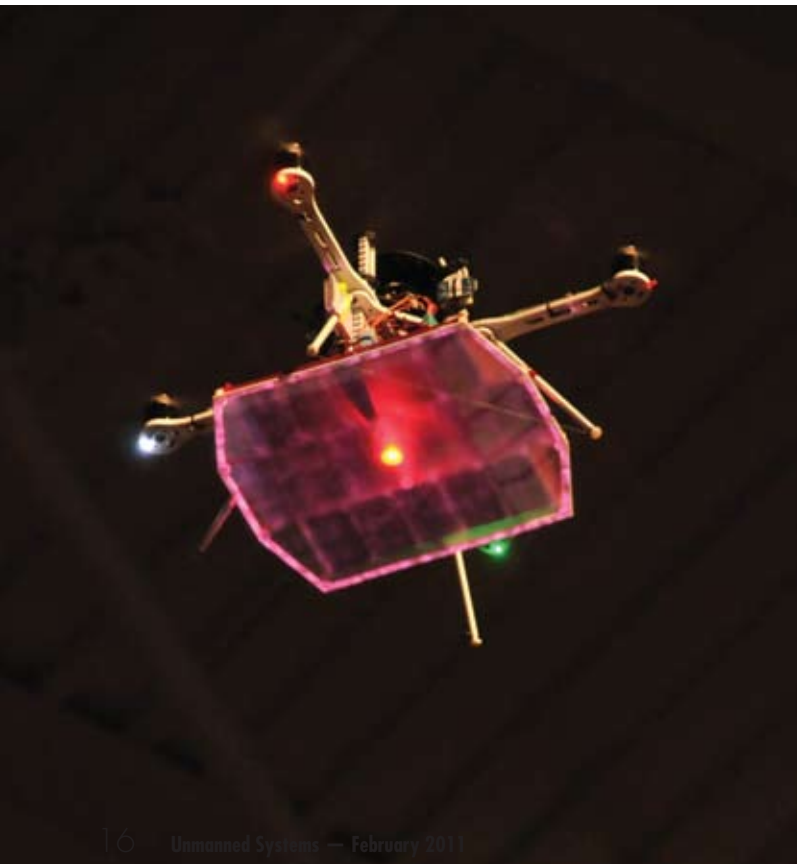
By Lee Ewing

Two recent advances in laser technology herald promising new capabilities for small unmanned aerial systems.

In one instance LaserMotive, a research and development company in Kent, Wash., has successfully demonstrated a new propulsion method for small UAS that could vastly extend their flight endurance. On 27 Oct., 2010, LaserMotive used laser power beaming — the wireless transfer of energy over distances by laser light — to propel a small unmanned quadrocopter and keep it hovering for 12 hours, 26 minutes and 56.9 seconds, a world record for small UAS.

Another significant development that offers new capabilities for small UAS is the advent of laser designators with sharply reduced size and weight. For years, UAS have employed laser target designation systems. Medium-altitude, long-endurance unmanned aerial systems such as the General Atomics MQ-9 Reaper and MQ-1 Predator find and fix targets with laser beams which laser-guided missiles and bombs follow to the target.

Smaller UAS like the AAI RQ-7B Shadow and Northrop Grumman MQ-8/RQ-8 Fire Scout now can employ similar laser targeting systems. And recent progress in the miniaturization of laser designators enables even smaller UAS to track targets and mark them for destruction.



LaserMotive powered this Pelican quadrocopter using lasers for more than 12 hours, a world record.

Power Beaming

Laser power beaming could give small electric-powered UAS an unlimited power supply so they could remain in operation virtually forever. In its recent demonstration LaserMotive, teamed with Ascending Technologies (AscTec) GmbH of Krailling, Germany, employed a modified AscTec Pelican quadrocopter, which weighs about one kilogram (2.2 pounds), for the world record flight.

LaserMotive gained attention earlier when it won NASA's Space Elevator Level 1 prize of $900,000 on 6 Nov., 2009 (for more information on that competition, see the January 2010 issue of *Unmanned Systems*). In that competition the company used wireless laser energy to power a climbing robot as it scaled a 900-meter-long tether held taut by a hovering helicopter in as little as three minutes, 48 seconds.

Tom Nugent, president of LaserMotive, says his company sought to apply lessons learned in the space elevator project to the demonstration of laser power beaming of the AscTec Pelican UAS.

"What we did was adapt our photovoltaic receiver technology, mounted on the bottom side of their quadrocopter … with an onboard battery and charging system and then integrated our tracking system with their navigation system," Nugent says.

The Pelican relies on GPS guidance when operating outdoors, but because this test was to be done indoors, where there would be no GPS signal, "We were sending up our tracking data to the Pelican so it could use that as a substitute for a GPS so it could know where it was."

In the test the team launched the Pelican using its five-minute-duration battery and then turned on the laser power beam to provide continuous energy.

"It just sat there, 35 or 40 feet in the air, hovering constantly for almost 12 and a half hours."

The Pelican's battery was recharged in flight, and near the end of the test the craft flew over the spectators and landed under battery power.

One limitation of UAS relying on laser power beaming is that a line of sight is necessary, but Nugent says several static or mobile laser power beaming systems could be deployed to mitigate the issue. The relatively low efficiency of current laser systems is another limitation, he acknowledges, but he expects efficiency to increase over the next few years. And while adverse weather can hamper laser power beams,

Nugent concedes, he says small UAS likely would not be very useful under such conditions.

Rotorcraft require more power than a fixed-wing aircraft of similar weight class, Nugent says. "So, if you can demonstrate keeping a helicopter up effectively forever, then [a fixed-wing] aircraft, by comparison, is relatively easy."

LaserMotive is seeking funding for further product development and for larger scale demonstrations of laser power beaming for aerostats, airships and small fixed-wing UAS such as the AeroVironment Puma AE, Nugent says.

"If we can get the right funding, we believe we could convert this into a full product, ready to ship, in 12 to 18 months."

While the laser power beam system used in the test drew its electricity from a power outlet in the test building, such systems also could use a generator or a vehicle's power supply.

"One of the areas where we've had a lot of interest in is for convoy protection, where they would like to have a small helicopter that could fly a little bit ahead of the convoy," Nugent adds. The helicopter could launch on battery power and fly on laser power, recharging as needed, performing long-endurance tasks such as searching the route ahead for improvised explosive devices.

"We have submitted a proposal to JIEDDO [Joint Improvised Explosive Device Defeat Organization] with a helicopter company and are waiting to hear on that."

Small, Lightweight Laser Designators

The U.S. Navy is one customer seeking high-performance laser designators that are light and compact enough for use on small UAS. The service on 19 Dec., 2009, issued a request for Small Business Innovation Research (SBIR) on a "Miniature Laser Designator for Small Unmanned Aircraft Systems." The system must be compact and weigh no more than one kilogram (2.2 pounds), including the gimbal used to point the designator, the request states.

In the first phase three companies demonstrated the technical feasibility of such a laser designator, a Navy spokesman said: Advanced Scientific Concepts Inc., of Santa Barbara, Calif.; Agiltron, Inc., of Woburn, Mass., and SA Photonics of Los Gatos and San Carlos, Calif.

In the second phase one or more contractors will be selected to develop, construct and demonstrate a prototype system. The third phase is for produc-

The Pelican UAV laser flight was done indoors without the use of GPS. Photos courtesy LaserMotive.

Elbit Systems' Rattler A laser designator. Photo courtesy Elbit Systems.

tion of a suitable laser designator and installation and testing of it on an Insitu ScanEagle or "other available similar UAV systems."

The SBIR request adds that the proposed small laser designator has "numerous commercial applications," including law enforcement, homeland security, surveillance, and search and rescue.

The U.S. Army is seeking a Lightweight Laser Designator Module for its Increment 2, Class I Unmanned Aerial Vehicle, a Honeywell T-Hawk 17-pound ducted fan vertical-takeoff-and-landing rotorcraft which can hover and stare. Fibertek Inc., of Herndon, Va., has developed a small laser for DRS Defense Solutions, of Bethesda, Md., which has integrated it into a multi-sensor gimbal weighing only 7.25 pounds.

"The Class I EO/IR/LD/LRF sensor gives the Class I UAS day and night capability for reconnaissance, surveillance, target acquisition and location, along with the capability to accurately bring laser guided weapons to bear on targets," DRS says on its website.

Fibertek's director of program development, Gary Stevenson, says customers generally want laser designators for use in a multi-sensor gimbal weighing 10 pounds or less. His company offers laser designators weighing as little as one pound.

"The key to this new generation of lasers is … athermal laser technology," Stevenson says. Athermal lasers, unlike earlier versions, are not sensitive to temperature. Early lasers used flash lamps to pump light into a laser medium, but they were very inefficient, he says. The next step forward was the diode-pumped laser, which was more efficient than the flash-pumped laser it replaced.

Fibertek is a pioneer in diode-pumped lasers, which have been in common use for decades, Stevenson says.

The next "quantum leap" in laser technology, he says, was the athermal diode-pumped laser, which Fibertek helped develop at the Army's Night Vision and Electronic Sensors Directorate at Fort Belvoir, Va. While traditional diode-pumped lasers required a heating and cooling system to stabilize temperature, athermal diode-pumped lasers do not, Stevenson explains.

"Athermal lasers use multi-colored laser diode bars which emit across a small region and … you can let the laser diode temperature float across a wide temperature range without requiring a thermal control system," he says. "Basically, athermal lasers allow you to dump the thermal control system overboard."

This recent breakthrough in laser technology allows Fibertek and others to develop very light and compact laser designators for use on small UAS.

"For the diode-pumped lasers the smallest one we were building was in the order of about seven pounds, and that was for a fairly powerful

For Small Unmanned Aerial System, a New Peril: Laser Weapons

Unmanned aerial systems can benefit from recent advances in laser technology, but at least one set of the maturing technologies poses a new threat: high-power laser weapons, which can set them ablaze at the speed of light.

In a prominent demonstration last year a U.S. Navy ship fired a 32-kilowatt solid-state laser weapon guided by a Raytheon Phalanx close-defense system's sensor suite and destroyed four UAS over the Pacific Ocean. This Laser Weapons System (LaWS) combined the power of six fiber lasers to illuminate and burn the target UAS.

"These engagements validate the operational viability of the Phalanx-LaWS combination at sea," Taylor W. Lawrence, president of Raytheon Missile Systems, said in announcing the feat. "The Raytheon-Navy team demonstrated the systems' capability to detect, track, engage and defeat dynamic targets at tactically significant ranges in a maritime environment."

The shipboard tests were considered important because they demonstrated that the LaWS could be effective despite the rigors of a maritime environment. They followed a series of Navy tests at China Lake, Calif., in 2009 in which a ground-based LaWS shot down five UAS.

While the addition of laser beams to the wide array of weapons than can shoot down small UAS poses a new challenge for those who build and use UAS, they can take comfort in the knowledge that even small UAS can deliver many of the capabilities of manned aircraft at lower cost and, most important, without risking a pilot's life.

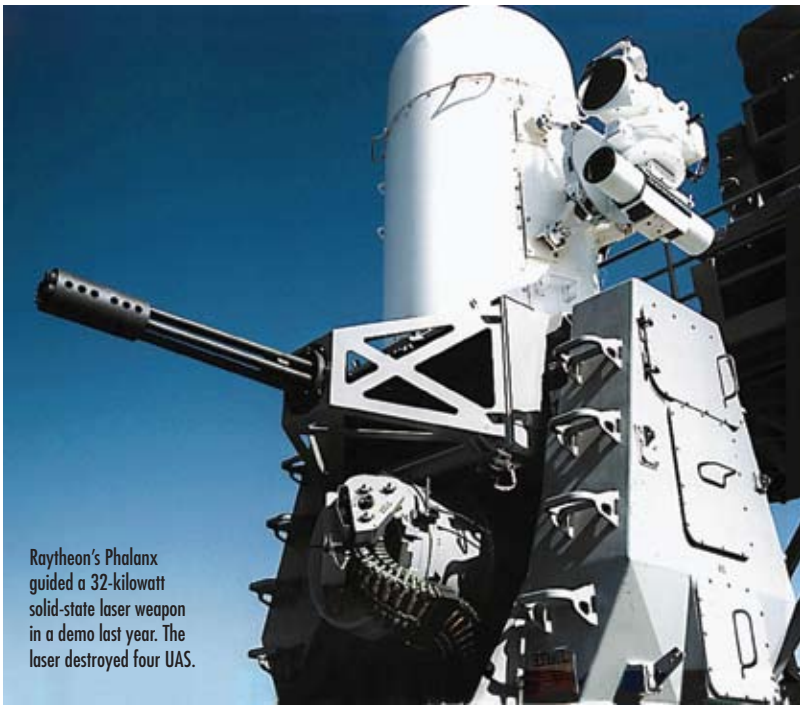
designator," Stevenson says. "That same designator today, we could get the weight down by half."

Another factor that has facilitated the miniaturization of laser designator is that over the years customer requirements for energy output have been reduced from 100 mJ (milliJules) to as little as 30 mJ, the level specified in the Navy SBIR.

Elbit Systems Electro-Optics Elop of Haifa, Israel, also uses athermal diode-pumped laser technology in its Rattler A, a compact 30-mJ coded laser designator for use on small UAS that weighs about a pound.

"The increasing demand for advanced laser systems, specifically miniaturized designators, is due to their ability to perform with high precision and prevent collateral damage," Adi Dar, the company's general manager, said in an Elbit announcement. "Our advanced laser solutions, including our miniaturized Rattler designator for small airborne and ground applications, have enabled bringing precision targeting to use on a wider scale."

Lee Ewing is the former editor of Aerospace Daily & Defense Report and Homeland Security magazine and is a frequent contributor to Unmanned Systems.



Raytheon's Phalanx guided a 32-kilowatt solid-state laser weapon in a demo last year. The laser destroyed four UAS.

Watch LaserMotive's laser-powered flight feat by scanning this barcode with your smart phone.

For More Information:

www.fibertek.com

http://lasermotive.com