Small, Birdlike UAS to Provide Eyes in the Sky for Soldiers

ARMY NEWS SERVICE (MAY 29, 2018)
David Vergun

WASHINGTON—The Army has plans to purchase 61 Black Hornet III small unmanned aerial systems, or SUASs, which are designed to provide reconnaissance support at squad level.

By the third quarter of next year, 57 of those systems will be fielded to a yet-unidentified Infantry brigade combat team, said Capt. WaiWah Ellison, the assistant program manager for Soldier Borne Sensors, part of Program Executive Office Soldier.

Ellison spoke during the "Close Combat Lethality Tech Day" demonstration, May 24, at the Pentagon.

The Black Hornet III can fly a distance of up to two kilometers and remain aloft for 25 minutes, she said.

The system takes color photographs and videos and can do so simultaneously, she noted. The system is also equipped with thermal imaging, which gives it night vision capability.

Most importantly, the Black Hornet III weighs less than two ounces. With Soldiers carrying so much gear, reducing their load is a top priority for everything PEO Soldier produces. Hauling around too much weight results in fatigue and reduces the ability of soldiers to maneuver on the battlefield when dismounted, Ellison explained.

The Black Hornet III comes with a docking station, where the batteries are charged, and with a monitor, which is about the size of a tablet computer, she said. The SUAS, docking station and monitor have a combined weight of less than three pounds. While the Black Hornet III is aloft, another battery can be charged and ready when it returns.

Wireless commands and data sent between the soldier and Black Hornet III are encrypted, Ellison said, to ensure the system is not susceptible to being hacked.

The Black Hornet III is not designed for long-term surveillance. Instead, it is designed to give soldiers a quick look at what's ahead of them, over a hill, or on the other side of a building or wall, she explained.

Sgt. Justin L. Bertoniere, 3rd Brigade Combat Team, 10th Mountain Division, looks at his display as he prepares to launch the Black Hornet III during field testing at Fort A.P. Hill, Va.
U.S. Army photo by Kyle J. O. Olson

After laboratory testing in early January at Fort Belvoir, Virginia, Aberdeen Proving Ground, Maryland, and at U.S. Army Natick Soldier Research, Development and Engineering Center in Massachusetts, the Black Hornet III was put through its paces at Fort A.P. Hill, Virginia, beginning in late January. The "fly-off" gave soldiers from the 3rd Brigade Combat Team, 10th Mountain Division, a chance to evaluate it in tactical conditions, she said.

It takes roughly 16 hours to train a soldier on how to pilot and maintain the Black Hornet III, she said, adding that operating it is fairly intuitive.

To fly it, you hold it in your hand and rotate it 90 degrees one way, then 90 degrees the other way, Ellison explained. That wakes it up and gets the rotor spinning. You also turn on the monitor and it acquires a GPS signal. The entire operation from turning everything on to flight is a bit over a minute.

During the fly-off, Ellison said soldier feedback was positive. Soldiers liked the system's reliability, saying it went where they wanted it to go and did not lose control sequences that were transmitted to it.

Don Sheehan, Integrated Product Team Lead for Small Unmanned Aerial Systems at Naval Air Systems Command, said the Navy had observers at Fort A.P. Hill during testing, as Marines and Special Operations operators are interested in the capabilities of the Black Hornet III and are likely to purchase a number of them.

Sheehan noted that the Black Hornet III is so quiet that during testing, one soldier was unaware that one of them was flying a few feet behind him.

Besides being stealthy, the Black Hornet III in its grey paint, is practically invisible in the forest or jungles and even if seen, could easily be mistaken for a small bird or large insect, he said.

Ellison noted that Black Hornet III is by no means the only model of SUAS that the Army is interested in. AeroVironment and InstantEye Robotics also participated in the competition and are expected to be back again with prototypes, ready for testing.

More testing of the Black Hornet III and other types of SUAS from different vendors will take place in October at Redstone Arsenal, Alabama, by soldiers from 7th Infantry Division, based at Joint Base Lewis-McChord, Washington, she said.

There will be a number of industry days coming up where vendors can tout their own SUAS prototypes, she said.

Army Researchers Developing High-Performance, Lightweight Helmet

DEPARTMENT OF DEFENSE NEWS (JUNE 7, 2018)
C. Todd Lopez

WASHINGTON—Army researchers in Massachusetts are developing technology that may soon yield a lightweight combat helmet that provides more protection than anything ever fielded.

Decision Making

Representatives of the U.S. Army Natick Soldier Research, Development and Engineering Center, Natick, Massachusetts, had an array of combat helmets on display at the Pentagon, May 24–25, as part of a "Close-Combat Lethality Tech Day."

Included among that protective gear was the Personnel Armor System for Ground Troops, or PASGT helmet, first fielded in 1981; the Advanced Combat Helmet, or ACH, first fielded in 2003; and the Lightweight Advanced Combat Helmet, or LW-ACH, which first appeared in 2013.

New Materials

All three of those helmets make use of para-aramid fibers to protect soldiers, and each successive helmet weighed less than its predecessor. The LW-ACH for instance, is more than a half-pound lighter than the PASGT helmet for a size large.

Newer helmets on display made use of a different material—ultra-high molecular weight polyethylene, or UHMWPE.

The Advanced Combat Helmet Generation II, for example, weighs 22 percent less than the ACH and is designed to protect soldiers from fragmentation as well as from rounds up to 9 mm.

The Enhanced Combat Helmet and the most-recently fielded Integrated Head Protection System, or IHPS, with ballistic applique provide protection against rifle fire, as well. That increased protection, however, comes at a cost in terms of weight.

The helmet display made clear the challenge posed to those responsible for designing gear that keeps solders safe.

Minimizing Helmet Weight

"There's kind of a competition between increased threat and weight," said Richard Green, the director of the Soldier Protection and Survivability Directorate at NSRDEC. "We want to protect against increased threat, while minimizing the weight. That's our goal."

The centerpiece of the NSRDEC helmet display, the NSRDEC prototype helmet, met the protection versus weight challenge head on.

Weighing in at just 2.5 pounds for the shell, and an estimated 3.5 pounds final weight, the NSRDEC prototype provides the same protection as the currently fielded IHPS.

But the NSRDEC prototype doesn't require the modular IHPS ballistic applique that attaches over the base helmet. With that applique in place, the IHPS system weighs over five pounds. The NSRDEC prototype weighs less than half that and provides the same protection. It protects soldiers against fragmentation, against 9 mm weapons fire, and against what Green called a "prevalent rifle threat."

Army Capt. Beverly Nordin and Command Sgt. Major James LaFratta, the 173rd Airborne Brigade Support Battalion's operations officer and command sergeant major, respectively, make decisions about the employment of heavy machine guns as their paratroopers conduct a base defense live-fire exercise in Slovenia. Army researchers are currently working on a helmet prototype that will provide equal protection as earlier helmets, but at less weight.
U.S. Army photo by Lt. Col. John Hall

The NSRDEC prototype helmet is made of the same class of material as the IHPS, the ECH, and the ACH GEN II: UHMWPE. But what researchers at NSRDEC have done is develop new ways to process UHMWPE so that it will be stronger than it has been in the past.

"It's stronger, so you need less of it," Green said.

Improved Performance

The new processing methods NSRDEC researchers have developed for UHMWPE has improved the ballistic performance for that material within a helmet. That means soldiers may one day see a finished helmet that weighs the same as the ECH, but provides more protection.

"The processing of that material has enabled us to optimize its performance," said Kenneth Ryan, the Warfighter Protection branch chief at NSRDEC. "Decreasing the load helps optimize soldier performance, and that helps them to be more lethal."

The NSRDEC doesn't manufacture helmets for the Army. Instead, it is the defense industry that ultimately provides that function, Ryan said. But when the time comes, it'll be NSRDEC-conducted research that industry will use to make the next generation of helmets that will help keep soldiers safe on the battlefield.

Ryan said he expects it will be about 12 months before these advanced technology developments that yielded the current incarnation of the NSRDEC prototype helmet can move forward to a point where the Army may request industry to develop mass-produced helmets for fielding to soldiers.

U.S. Must Act Now to Maintain Military Technological Advantage, Vice Chairman Says

DEPARTMENT OF DEFENSE NEWS, DEFENSE MEDIA ACTIVITY (JUNE 21, 2018)
Jim Garamone

WASHINGTON—The United States must act or China will achieve its goal of equaling American technological prowess by 2020 and surpassing it by the 2030s, the vice chairman of the Joint Chiefs of Staff said here today.

Air Force Gen. Paul J. Selva said DoD is working on technologies to keep the U.S. military superior to the Chinese and stressed the need to safeguard critical technologies. He took part in a panel discussion at the Center for a New American Security's annual conference this morning.

China has announced goals to have technological parity with the United States in the early 2020s and surpass America in the next decade, the general said. This could happen, Selva said, but it presumes the United States won't react to the challenge.

China and Russia are doing their best to offset American capabilities in the Western Pacific and in Europe, he said. In both cases and areas, the United States must protect the nation's greatest military advantage: the ability "to project American power when and where it is in our national interests," Selva said.

Air Force Gen. Paul J. Selva, vice chairman of the Joint Chiefs of Staff, answers a question from the audience during the Center for New American Studies 2018 Annual Strategic Competition Conference in Washington, D.C., June 21, 2018. Discussion topics included threats to U.S. competitive advantages and potential counter strategies.

DoD photo by Army Sgt. James K. McCann

Preventative Power Projection

If the American military fails at projecting power into situations where interests are threatened, then it fails the American people, the general said.

"This is not about trying to counter an anti-access, area denial strategy—that's admitting defeat up front and saying we have to go back and fix something we broke," he said.

Selva proposed an alternate approach of analyzing what the opponent is trying to do, and "make this a competition, not a conflict, and checkmate them or prevent them from getting so much an advantage that they can prevent you from doing the things that are in your national interests."

This is spelled out in the National Security Strategy and National Defense Strategy, he said. "If we sit back and don't react, we will lose our technological superiority in 2020—the Chinese are right," the general said. "But we should be a player in this game, not an observer."

The United States is doing significant research and development in a number of key technologies, including: long-range strike capability, artificial intelligence, and hypersonics, he said. "We are way ahead in the sensor and sensor-integration technologies," Selva said.

This last is important as the United States must protect technologies like this to maintain its advantage, the general said.

"[We] have to protect what we have, because the Chinese, if they can't learn about it, they will try to buy it; and if they can't learn about it or buy it, they will steal it," he said. "We know they are active in all three domains—learning, buying, or stealing—so we have to be careful to defend the technologies that are important to us, while we continue to develop additional capabilities."

Networks, Innovation Key to Air Force Philosophy

DEPARTMENT OF DEFENSE NEWS, DEFENSE MEDIA ACTIVITY (JUNE 26, 2018)
Jim Garamone

WASHINGTON—Building networks and continuing innovation are key to success in the future, Air Force leaders said at the Defense One Tech Summit here today.

Tech Summit

Richard J. Joseph, the Air Force's chief scientist, and Mark Tapper, a special advisor on intelligence, surveillance, and reconnaissance at the Service, spoke to Military.com's Oriana Pawlyk during a panel discussion.

Both men said that Air Force culture must change to ensure the Service can handle future threats.

"Everyone seems to recognize that the threat we face has evolved to the point where it is a real challenge to us," Joseph said. "In order to address that, we are going to do things differently—not just having new technologies, but we're going to have to have new approaches."

If the Service fails to adapt to this new culture, it will lose confidence of leaders and innovation will then lose priority, Joseph said. "It is up to us to fix all these things at once," he added.

Seeking Dominance

China and Russia and some of the smaller players have access to technology that allows them to become significant opponents. "We should not be just following their lead. We should be looking at this in a grand way and try to decide where we need to go to retain dominance," the chief scientist said.

New technology is great, Tapper said, but he wants an answer to the question, "New technologies to do what?" It comes down to using new tools and data to combat what leaders believe the future threats will be, he explained.

At its core, the Air Force projects American military might with speed and power, and, if necessary, with persistence, the officials said. But some communities within the Service look at problems via a narrow lens, they acknowledged—the airlift community, for example, would come up with an airlift solution, the air combat community with an air combat community, and so on.

Joseph said there needs to be a way for communities to share a common viewpoint and that these communities should also share data so all communities can benefit.

Both men agreed that the United States shouldn't just look at the threats posed by Russia and China, and devise counters to them. Rather, they said, the military should look to see where potential threats are not operating in order to be ahead of potential threats and to force potential adversaries to invest in ways to counter American developments, rather than the other way around.

DoD Releases National Defense Business Operations Plan

DEPARTMENT OF DEFENSE OFFICE OF THE CHIEF MANAGEMENT OFFICER (JUNE 27, 2018)

WASHINGTON—The 2018 National Defense Strategy clearly articulates the Department of Defense's mission to compete, deter, and win in an increasingly complex security environment while executing objectives in the most efficient and effective manner throughout the enterprise. To best align the department's daily efforts to this mission, the Office of the Chief Management Officer has developed the National Defense Business Operations Plan.

The National Defense Business Operations Plan supports the 2018 National Defense Strategy and replaces the department's Agency Strategic Plan. Within the National Defense Business Operations Plan is the Fiscal Year 2019 Annual Performance Plan, which details action plans for each performance goal. These specific targets are used to gauge the department's progress in achieving success, as defined by the National Defense Strategy and the National Defense Authorization Act.

All Department of Defense personnel should take time to read and understand this plan, and incorporate the Annual Performance Plan into regular routine. As the Annual Performance Plan is revised each Fiscal Year, the Office of the Chief Management Officer will publish and update it **here**.

SecAF Wilson Talks Air Force Innovation Across JBSA, Austin

502ND AIR BASE WING PUBLIC AFFAIRS (July 2, 2018)
Senior Airman Stormy Archer

JOINT BASE SAN ANTONIO, Texas—Secretary of the Air Force Heather Wilson visited AFWERX-Austin, Pilot Training Next and Joint Base San Antonio, Texas, June 27–29, 2018, to see firsthand the focus airmen in the area are placing on improving readiness, cost-effective modernization, and developing exceptional leaders.

Her first stop was AFWERX-Austin, the Air Force's newest public innovation and collaboration hub focused on bridging external communities and the Air Force to create mutually beneficial partnerships.

"We recognize that the bureaucracy doesn't always allow innovation to happen, and that's one of the reasons for creating things like AFWERX," Wilson said. "To take some of the innovative capacities of the people who work in high-tech companies who can help the Air Force connect with a community that has a university partner, where we're very likely to find entrepreneurial talent and ideas, a supportive local government, a business and innovation culture, and try to connect and embed as part of a team."

Secretary of the Air Force Heather Wilson visited AFWERX-Austin June 27, 2018. During her visit to Texas, Wilson learned more about the mission at AFWERX-Austin, Pilot Training Next, 12th Flying Training Wing at Joint Base San Antonio-Randolph and Basic Military Training Wing at JBSA-Lackland.

U.S. Air Force photo by Senior Airman Gwendalyn Smith

Wilson also toured the Pilot Training Next facility at Austin-Bergstrom International Airport in Austin.

Pilot Training Next is a program to explore and potentially prototype a training environment that integrates various technologies to produce pilots in an accelerated, cost efficient, learning-focused manner. The training uses immersive technology to see how airmen can learn more effectively.

"Technology has changed quite a bit, but the syllabus for pilot training had not significantly changed in about 20 years," Wilson said. "The Air Force is partnering with industry and educators to build a training environment that integrates today's latest technology to improve pilot training."

The next stop for Wilson was a visit to Joint Base San Antonio.

At JBSA-Randolph, Wilson met with members of the 12th Flying Training Wing to discuss the pilot instructor training, introduction to fighter fundamentals, weapons systems officer training, remotely piloted aircraft pilot, and basic sensor operator training missions.

While at JBSA-Lackland, Wilson had the opportunity to engage with new airmen and their families, and also serve as the reviewing official during the Basic Military Training graduation parade. There she welcomed 628 new airmen into the Air Force.

"To our newest airmen, every one of you comes here with a story," Wilson said. "You bring with you your history and your family's history to our nation's defense, and you are now part of our story as airmen in the greatest Air Force in the world."

The Department of Defense Announces its Digital Engineering Strategy

DEPARTMENT OF DEFENSE NEWS RELEASE (JULY 5, 2018)

Under Secretary of Defense for Research and Engineering Michael Griffin released the Department of Defense Digital Engineering Strategy today.

The strategy promotes the use of digital representations of systems and components and the use of digital artifacts to design and sustain national defense systems. The department's five strategic goals for digital engineering are:

- Formalize the development, integration, and use of models to inform enterprise and program decision making
- Provide an enduring, authoritative source of truth
- Incorporate technological innovation to improve the engineering practice

- Establish a supporting infrastructure and environment to perform activities, collaborate and communicate across stakeholders
- Transform the culture and workforce to adopt and support digital engineering across the life cycle

The DoD Digital Engineering Strategy can be found on the DoD Systems Engineering website.

Headquarters Merger Streamlines Logistics, Resources for Nuclear Enterprise System Management

AIR FORCE MATERIEL COMMAND (JULY 9, 2018)
Marisa Alia-Novobilski

WRIGHT-PATTERSON AIR FORCE BASE, Ohio—In an effort to increase synergy and coordination in support of the Air Force's nuclear modernization efforts, two Air Force Materiel Command directorates merged to form a single Logistics, Civil Engineering, Force Protection, and Nuclear Integration Directorate. The organizational change took effect June 25, 2018.

"This change will enable us to better streamline and coordinate logistics support for the Air Force as it modernizes and continuously improves the nuclear enterprise," said Brig. Gen. Allan Day, director of the newly merged organization. "This merger will help synchronize our nuclear integration efforts with our other relevant core competencies of maintenance, logistics, force protection, and civil engineering."

The combined directorate's mission is to shape the workforce and infrastructure to provide logistics, sustainment, and installation support for Air Force weapon systems, acquisition logistics, supply management, depot maintenance, and nuclear integration.

The reorganization aligns AFMC to other major command structures such as that of Air Mobility Command and the U.S. Air Forces in Europe, each of which has a combined directorate to oversee Operations, Strategic Deterrence, and Nuclear Integration. The merger also raised the grade of the AFMC headquarters staff nuclear principal to that of flag officer, helping to better posture the command to support nuclear enterprise capabilities that span logistics and product support to oversight of weapons storage facilities and maintenance of ground-based strategic deterrent systems.

"New as well as legacy nuclear enterprise systems require resources and personnel to support fielding and sustainment, which considerably impacts our oversight responsibilities and resourcing decisions," said Day. "This merger will allow us to reallocate our resources more efficiently to meet the Air Force nuclear modernization efforts."

The new directorate has eight divisions, which include Civil Engineering, Product Support Management, Maintenance, Systems, Resource Integration, Logistics Readiness, Security Forces and Nuclear Integration. There were no changes in manpower numbers as a result of the reorganization.

The two merged directorates were formerly known individually as the Logistics, Civil Engineering and Force Protection Directorate, or A4, and the Strategic Deterrence and Nuclear Integration Directorate, or A10. The new directorate retains the A4/10 designation.

Similar mergers have occurred at other Air Force major commands to better align forces for the agile, integrated, multi-domain operations of the future.

'Exciting, Crucial' Time in AI Development, Official Tells Innovation Board

DEPARTMENT OF DEFENSE NEWS, DEFENSE MEDIA ACTIVITY (JULY 12, 2018)
Lisa Ferdinando

WASHINGTON—Artificial intelligence is a strategic priority for the Defense Department that could transform the way the department operates, the head of machine learning at the Defense Innovation Unit Experimental said yesterday.

"We are in the midst of an exciting and crucial time in the development of AI," Brendan McCord told a meeting of the Defense Innovation Board, held at DIUx headquarters in Mountain View, California.

McCord pointed out the recent announcement of the creation of DoD's Joint Artificial Intelligence Center, or JAIC, saying it is an effort that is significant to the department and the country. "Structurally, we know that AI has the potential to be an enabling layer across nearly everything," he said, explaining it means countless applications in daily life and could affect all areas of the department.

AI provides the opportunity for humans to "see more deeply, to act with greater precision, to be offered more choices and scenarios, offered better advice," McCord said, adding that it "changes the nature of things."

Affecting a Variety of Tasks

Artificial intelligence could affect the way the department does a variety of tasks, such as maintaining equipment, perceiving its environment, training and protecting its members, defending its networks, operating its back office, providing humanitarian aid, and responding to disasters, he said.

A storage container used for maintaining missile launch facilities and control centers is displayed at Hill Air Force Base, Utah. A recent merger between the Air Force Materiel Command Logistics, Civil Engineering and Force Protection Directorate and the Strategic Deterrence and Nuclear Integration Directorates aims to better align AFMC efforts to support Air Force nuclear modernization missions.

U.S. Air Force photo by Todd Cromar

He highlighted four themes of the JAIC: improving the ability to translate the technology into decisions and impact; helping the department evolve partnerships with industry, academia, allies, and partners; attracting and cultivating world-class talent; and supporting the goals of the National Defense Strategy.

Defense Innovation Board Executive Director Joshua Marcuse said multiple agencies are making progress on projects that align with the board's recommendations. He highlighted several of those areas: embedding computer science as a core competency; catalyzing innovation in AI and machine learning; implementing acquisition innovation; expanding new approaches to innovation; embedding technical teams at major commands; making computing and bandwidth abundant; taking a new approach to data; and establishing tech and innovation training for senior leaders.

Building Innovation Capacity with Allies, Partners

The DIB is a federal advisory board that launched in April 2016 with a two-year, renewable mandate. It comprises private-sector leaders and innovators to provide recommendations to the secretary of defense and other senior defense leaders in an effort to improve DoD's processes and apply best practices.

The agenda at yesterday's quarterly meeting included building innovation capacity with allies and partners, in support of a National Defense Strategy priority of strengthening alliances and creating new partnerships.

"I cannot be prouder of the progress that has occurred," DIB Chairman Eric Schmidt, technical advisor to the board of Alphabet Inc., said as he closed the meeting, pointing out that senior leaders really want to address the underlying challenges they face.

The board's last previous meeting was in April in Boston. The next meeting is set for October in the national capital area.

Faster, Lighter, Smarter: DARPA Gives Small Autonomous Systems a Tech Boost

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY OUTREACH (JULY 18, 2018)

Defense Advanced Research Projects Agency (DARPA)'s Fast Lightweight Autonomy (FLA) program recently completed Phase 2 flight tests, demonstrating advanced algorithms designed to turn small air and ground systems into team members that could autonomously perform tasks dangerous for humans—such as pre-mission reconnaissance in a hostile urban setting or searching damaged structures for survivors following an earthquake.

Building on Phase 1 flight tests in 2017, researchers refined their software and adapted commercial sensors to achieve greater performance with smaller, lighter quadcopters. Conducted in a mock town at the Guardian Centers training facility in Perry, Georgia, aerial tests showed significant progress in urban outdoor as well as indoor autonomous flight scenarios, including:

- Flying at increased speeds between multi-story buildings and through tight alleyways while identifying objects of interest;
- Flying through a narrow window into a building and down a hallway searching rooms and creating a 3-D map of the interior; and
- Identifying and flying down a flight of stairs and exiting the building through an open doorway.

Begun in 2015, the FLA applied research program has focused on developing advanced autonomy algorithms—the smart software needed to yield high performance from a lightweight quadcopter weighing about five pounds with limited battery power and computer processing capability onboard. FLA's algorithms have been demonstrated so far on air vehicles only, but they could be used on small, lightweight ground vehicles as well.

"The outstanding university and industry research teams working on FLA-honed algorithms that in the not too distant future could transform lightweight, commercial-off-the-shelf air or ground unmanned vehicles into capable operational systems requiring no human input once you've provided a general heading, distance to travel, and specific items to search," said J.C. Ledé, DARPA program manager. "Unmanned systems equipped with FLA algorithms need no remote pilot, no GPS guidance, no communications link, and no pre-programmed map of the area—the onboard software, lightweight processor, and low-cost sensors do all the work autonomously in real-time."

FLA's algorithms could lead to effective human-machine teams on the battlefield, where a small air or ground vehicle might serve as a scout autonomously searching unknown environments and bringing back useful reconnaissance information to a human team member. Without needing communications links to the launch vehicle, the chances of an adversary detecting troop presence based on radio transmissions is reduced, which adds further security and safety, Ledé said. This could be particularly important in a search-and-rescue scenario, where an FLA-equipped platform could search in radio silence behind enemy lines for a downed pilot or crew member.

During Phase 2, a team of engineers from the Massachusetts Institute of Technology and Draper Laboratory reduced the number of onboard sensors to lighten their air vehicle for higher speed.

"This is the lightweight autonomy program, so we're trying to make the sensor payload as light as possible," said Nick Roy, co-leader of the MIT/Draper team. "In Phase 1 we had a variety of different sensors on the platform to tell us about the environment. In Phase 2 we really doubled down trying to do as much as possible with a single camera."

A key part of the team's task was for the air vehicle to build not only a geographically accurate map as it traversed the cityscape, but also a semantic one.

"As the vehicle uses its sensors to quickly explore and navigate obstacles in unknown environments, it is continually creating a map as it explores and remembers any place it has already been so it can return to the starting point by itself," said Jon How, the other MIT/Draper team co-leader.

Using neural nets, the onboard computer recognizes roads, buildings, cars, and other objects and identifies them as such on the map, providing clickable images as well. The human team member could download the map and images from the onboard processor after the mission is completed.

Additionally, the MIT/Draper team incorporated the ability to sync data collected by the air vehicle with a handheld app called the Android Tactical Assault Kit (ATAK), which is already deployed to military forces. Using an optional Wi-Fi link from the aircraft (that the human team member could turn on or off as desired), the air vehicle can send real-time imagery of objects of interest. During the flight tests, researchers successfully demonstrated autonomous identification of cars positioned in various locations around the mock town. With "exploration mode" on, the air vehicle identified the cars and provided their location with clickable high-resolution images

Faster Lightweight Autonomy (FLA) Phase 2 Flight Testing
DARPA Image

in real-time via Wi-Fi, appearing as an overlay on the ATAK geospatial digital map on the handheld device.

A separate team of researchers from the University of Pennsylvania reduced their air vehicle's size and weight to be able to fly autonomously in small, cluttered indoor spaces. UPenn's air vehicle took off outside, identified and flew through a second-story window opening with just inches of width clearance, flew down a hallway looking for open rooms to search, found a stairwell, and descended to the ground floor before exiting back outside through an open doorway.

The platform's reduced weight and size brought new challenges, since the sensors and computers used in Phase 1 were too heavy for the smaller vehicle.

"We ended up developing a new integrated single-board computer that houses all of our sensors as well as our computational platform," said Camillo J. Taylor, the UPenn team lead. "In Phase 2 we flew a vehicle that's about half the size of the previous one, and we reduced the weight by more than half. We were able to use a commercially available processor that requires very little power for the entirety of our computational load."

A key feature of the UPenn vehicle is its ability to create a detailed 3-D map of unknown indoor spaces, avoid obstacles, and ability to fly down stairwells. "That's very important in indoor environments," Taylor said. "Because you need to actually not just reason about a slice of the world, you need to reason about what's above you, what's below you. You might need to fly around a table or a chair, so we're forced to build a complete three-dimensional representation."

The next step, according to Taylor, is packing even more computation onto smaller platforms, potentially making a smart UAV for troops or first responders that is small enough to fit in the palm of the hand.

Algorithms developed in the FLA program have been scheduled to transition to the Army Research Laboratory for further development for potential military applications.

Army Futures Command to Build on 3 Pillars 'to Ensure We Can Fight and Win'

ARMY NEWS SERVICE (JULY 18, 2018)
David Vergun

WASHINGTON—"We'll potentially be in a near-peer fight in the near future ... and it will be a difficult fight," said Lt. Gen. Paul A. Ostrowski, principal military deputy to the assistant secretary of the Army for Acquisition, Logistics and Technology and director of the Army Acquisition Corps, during an Association of the U.S. Army breakfast in Arlington, Virginia, July 18.

An AH-64 Apache helicopter takes off from a Forward Arming and Refueling Point during a 1st Battalion, 501st Aviation Regiment, Combat Aviation Brigade, 1st Armored Division, gunnery at Range 83 at Orogrande, N.M., April 23, 2018. Future Vertical Lift is one of the priorities of the new Army Futures Command.
U.S. Army photo by Winifred Brown

Peer competitors are already investing heavily in such things as hypersonics and electronic warfare, Ostrowski said. "We have to get after those pieces."

To counter these threats and help the Army maintain a decisive advantage over its adversaries, the new U.S. Army Futures Command will focus its energy on three pillars that will support modernization.

Ostrowski called the first pillar "Futures and Concepts." It is what the visionaries of the Futures and Concepts group within Futures Command will develop as they ask:

What will the battlefield look like in 2036?

- What are the tactics, techniques, and procedures needed to win in 2036?
- Will the current organization revolving around brigade combat teams still be relevant in 2036 or does there need to be a reorganization?
- How will quantum computing, high-energy lasers, directed energy weapons, hypersonics, and artificial intelligence change the nature of warfare by 2036?

While academia, science, and industry will inform these visionaries, Ostrowski suggested that they also look to Hollywood. "Think about it. How many things do we have in our hands today that you saw in movies growing up?"

The second pillar is Combat Development, which is the ability to take those aspects of Futures and Concepts and turn them into requirements. The Army Capabilities Integration Center personnel will be involved in that.

In the past, "the way we wrote requirements [was] in a vacuum," he said. "They were not informed requirements—technology was not informing them, testing was not informing them, and sustainment and logistics were not informing them. Now they are informing them."

Ostrowski described the third pillar of Combat Systems as taking what has been learned from Futures and Concepts and turning that into experimentation, prototyping and capabilities that can be tested by Soldiers who give their feedback.

In the past, "we didn't have Soldier touchpoints along the way to make sure we were doing the right thing," he said, referencing user testing during all aspects of research and development. "Now we do."

Army Futures Command, which will be headquartered in Austin, Texas, will be focusing on those three pillars for years to come, Ostrowski said.

"Futures Command is all about bringing together all the parts and pieces of the enterprise called modernization under one roof in order to get after the things that were missing all these years: agility, speed, and the ability to ensure we can fight and win not only today, but well into the future," Ostrowski said.

Army's New 3-D Printed Shape-Shifting Soft Robots Crawl, Jump, Grab

U.S. ARMY RESEARCH LABORATORY PUBLIC AFFAIRS (JULY 26, 2018)

ADELPHI, MD.—New 3-D printed robotic structures can squeeze in tight spaces like a crack in the wall of a cave, jump over trip wire, or crawl under a vehicle—all complex, Army-relevant functions impossible for humans to perform safely.

Investigators at the Army's Institute for Soldier Nanotechnologies, located at MIT, have developed a 3-D printing platform that can enable both the modeling and design of complex magnetically actuated devices. The new approach utilizes a 3-D printing platform fitted with an electromagnet nozzle and a new type of 3-D printable ink infused with magnetic particles. Their findings could lead to new biomedical applications, magnetic ink optimized to strengthen soft robotic functionality, and new on-demand flexible material systems for integration into Soldier systems.

Soft robotic capabilities and manufacturing at the point of need are among the Army's top research priorities.

This research is managed through the U.S. Army Research Laboratory's Army Research Office by Dr. Aura Gimm.

This research provided new insight on ways to cause fast changes in 3-dimensional shapes of parts such as robot's limbs, she said. "The MIT group demonstrated this success using auxetic metamaterials—synthetic composite materials that have an unusual internal structure and the unusual property that when exposed to external magnetic actuation, they shrank in both longitudinal and transverse directions.

This is different from typical auxetic materials that do require direct mechanical contact, and when compressed they undergo contraction in the directions perpendicular to the applied force (this is called the negative Poisson's ratio). On the contrary, common materials expand in the directions orthogonal to compressive load.

In one example from this research, through remote magnetic control, they caused a metamaterial structure to jump forward 120 mm within 0.7 s, which is very fast for the current state of the art. This jump was due to a rapid release of elastic and magnetic potential energy stored in that structure.

"Such complex shape-morphing structures could have great potential for the Army, because they may help create soft robots—robots with pliable limbs similar to natural organisms. Compared to the current generation of rigid robots, soft robots could move much more dexterously on a complex battlefield terrain," said Army Research Laboratory Dr. Alex Hsieh.

This technology may enable the future Army to fabricate magnetic 3-D printed structures that can crawl, roll, jump, or grab in support of Army relevant needs. This research effort enables controlling the magnetic orientation of newly 3-D printed devices so that they are able to rapidly change into new intricate formations or move about as various sections respond to an external magnetic field. Functions demonstrated from these complex shape changes include reconfigurable soft electronics, mechanical metamaterial that can jump, and a soft robot that can crawl, roll, catch fast moving objects, or deliver pharmaceuticals.

Although other groups have fabricated magnetically activated materials to accomplish simple movements, this new approach enables both the modeling and the design of magnetically controlled device sections to perform complex, Army-relevant soft robotic tasks.

The approach is based on direct ink writing of an elastomer composite containing ferromagnetic microparticles and the application of a magnetic field to the dispensing nozzle while printing. The technique reorients particles along the applied field to impart patterned magnetic polarity to printed filaments. This method allows the researchers to program fer-

romagnetic domains in complex 3-D-printed soft materials to enable a set of previously inaccessible modes of transformation. The actuation speed and power density of the printed soft materials with programmed ferromagnetic domains are orders of magnitude greater than existing 3-D-printed active materials.

"We have developed a printing platform and a predictive model for others to use. People can design their own structure and domain patterns, validate them with the model, and print them to actuate various functions. By programming complex information of structure, domain, and magnetic field, one can even print intelligent machines such as robots," said MIT Professor Xuanhe Zhao, an investigator at the Army's ISN.

This work aligns with Army modernization priorities that support future Army operations through support of ARL's extramural basic research campaign and the Army's Robotic and Autonomous Systems Strategy.

The Army's ISN Mission is to help the Army dramatically improve the protection and survivability of the Soldier by working at and extending the frontiers of nanotechnology through fundamental research and transitioning with Army and industry partners.

Army's New 3-D.jpg

Time-lapse photo for various designs of developed magnetic active material.
Courtesy photo illustration by MIT Soft Active Materials Lab