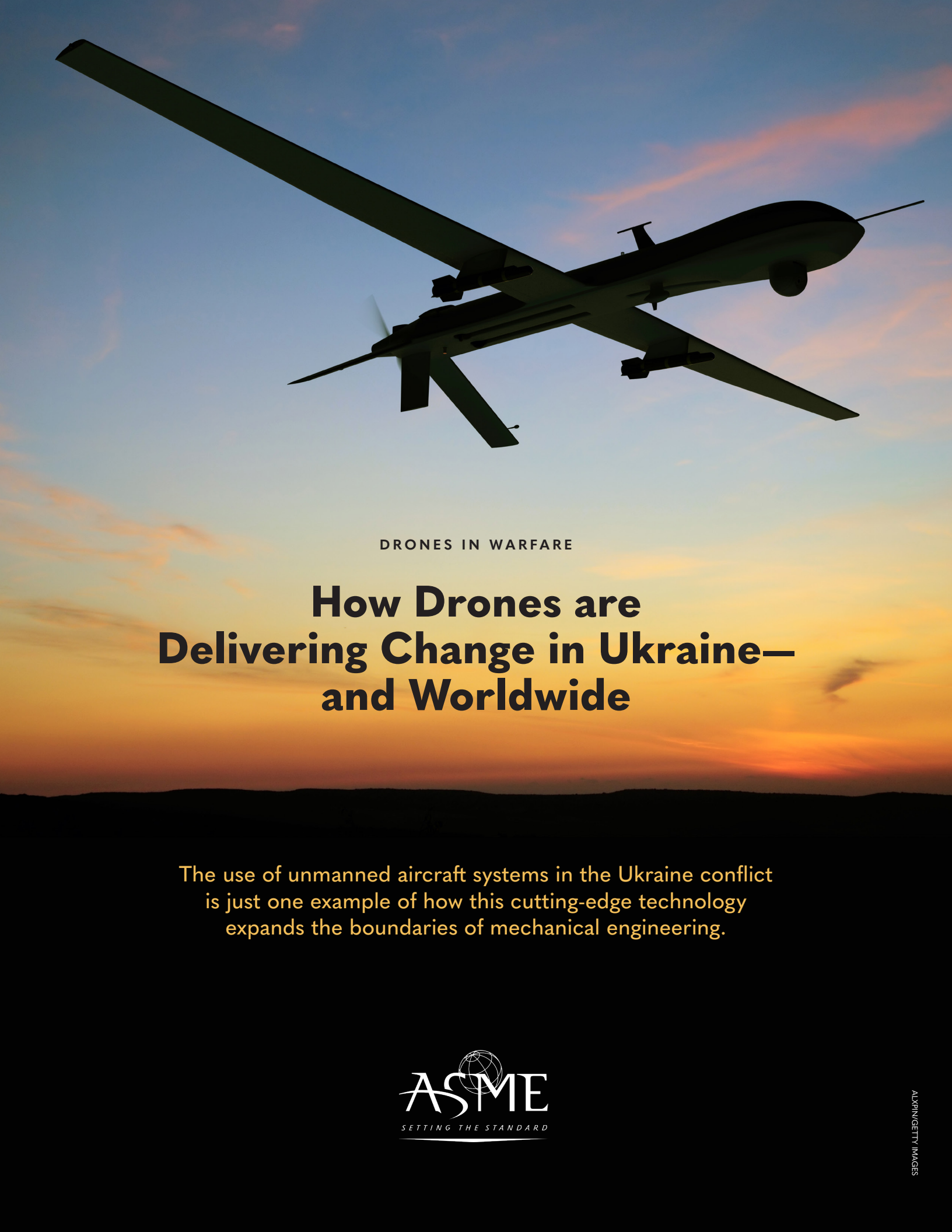


DRONES IN WARFARE

How Drones are Delivering Change in Ukraine—and Worldwide

The use of unmanned aircraft systems in the Ukraine conflict is just one example of how this cutting-edge technology expands the boundaries of mechanical engineering.

ASME
SETTING THE STANDARD

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As witnessed in the ongoing war in Ukraine, the armed conflicts of today rely heavily on unmanned aircraft systems (UAS), which have played an important role in defense as well as intelligence, reconnaissance, and medical response. The media has widely reported on Ukraine's ability to successfully and effectively use military drones against high-cost Russian targets such as armored vehicles and how Ukraine's utilization of UAS has changed the nature of warfare.

UAS represent the cutting edge of technology, a field existing at the boundaries of where mechanical engineering meets electrical engineering, software engineering, and computer sciences, according to Patrick Currier, professor and interim chair of the Mechanical Engineering Department at Embry-Riddle Aeronautical University.

"It's not what most people think of as mechanical engineering," Currier explains. "You're working in that area where you're combining different fields to make something that can operate itself. We take those mechanical things and control them to do what we want to do."

IN THE THEATER OF WAR

Unmanned aerial vehicles (UAV) vary significantly not only in size—ranging from as small as your hand to the size of a jet aircraft—but also in form, function, range, speed, and level of autonomy.

One type of drone that has been most effective as a tool for Ukraine since the start of the Russian invasion in February is the loitering missile, sometimes called a "kamikaze drone," a category of small UAS equipped with a munition that can wait passively in the air and attack once a target is identified.

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The loitering missile category of munition was first created more than a decade ago with the introduction of the AeroVironment Switchblade, which has gotten a great deal of press for its outsize role and impact in the early months of the Ukraine conflict.

The Switchblade offers many advantages over traditional artillery, including its ability to reach greater range, avoid detection, and maintain a safer standoff for forces, notes Cindy Jacobson, AeroVironment senior director of marketing and communications. She says that both the 300 and 600 variants of the Switchblade are "uniquely suited" for this type of conflict in Ukraine.

The smaller 300 model is launched from a tube and is able to fly for 15 minutes and more than 6 miles. It is sometimes referred to as a "backpack drone" because it's small enough to fit into one.

At 50 pounds, the larger 600 model is able to fly for 25 miles and loiter for 40 minutes, and it is designed for use against tanks and armored vehicles. "It can launch without having a target already identified, allowing soldiers to leave the site before being discovered," Jacobson explains, "and the operator can spend close to an hour looking for a target before striking."

The Switchblade has the ability to loiter undetected by the enemy within a designated area, and it features a unique, patented wave-off technology that allows an operator to abort a mission at any time.

Other UAS of various sizes used by Ukraine include:

- The Turkish-built Bayraktar TB2, a precision airstrike UAV that carries laser-guided munitions
- Phoenix Ghost tactical UAVs, kamikaze drones developed by the U.S. Air Force and AEVEX



Soldiers launch a Switchblade 300, which can fly for 15 minutes and more than 6 miles.

Aerospace that can also be used for intelligence, surveillance, and reconnaissance (ISR) purposes
- AeroVironment's Puma, a handheld UAS that complements the Switchblade by providing ISR
- The German Vector drone, for surveillance and reconnaissance
- The Ukrainian-built Punisher by UA Dynamics, a surveillance drone that can carry a small bomb

As the Ukraine conflict progresses, the Biden administration has considered selling armed drones such as General Atomics' MQ-1C Gray Eagle to Ukraine, which would be a step toward sending the country UAS that are larger and more sophisticated than weapons currently in use like the Switchblade. A medium-altitude, long-endurance UAS, the Gray Eagle can fly 30 or more hours, gather vast amounts of data, fire up to eight Hellfire missiles, and—unlike the Switchblade—be reused.

Today's UAS original equipment manufacturers (OEMs) need mechanical engineers on their teams to design drone prototypes, build and test drone systems, and help bring new drone designs to market.

As of this writing, Congress had not yet approved the United States sending Gray Eagles to Ukraine, but should that happen, it would be a big development for the Ukrainians, says Michael Robbins, executive vice president of government and public affairs at the Association for Uncrewed Vehicle Systems International (AUVSI).

Robbins believes the next big trend with military use of UAS will be "manned/unmanned teaming."

In late 2021, the U.S. Air Force committed to acquiring and flying "loyal wingman" UAVs, which are next-generation drones that fly with manned aircraft to add capacity to an airway. The Air Force Research Laboratory (AFRL) has also funded Skyborg, an autonomous aircraft teaming architecture that enables UAS to give military pilots key information about their surroundings when teamed. "Skyborg will not replace human pilots. Instead, it will provide them with key data to support rapid, informed decisions," according to AFRL.

AEROVIRONMENT

"This is a really interesting future trend that's being looked at by the military for all types of drones—not only aerial, but also maritime and ground systems."

"For example, a couple of F-35s or F-18s can have unmanned drones flying alongside them to provide situational awareness and real-time intelligence," Robbins explains, "as well as maybe also providing communications jamming or striking ability. This is a really interesting future trend that's being looked at by the military for all types of drones—not only aerial, but also maritime and ground systems."

PROVIDING WARTIME AID

In addition to playing a crucial role in combat, UAS are also being used to deliver essential intelligence and medical support to Ukrainian families and soldiers. For example, in early 2022, drone solutions and systems developer Draganfly Inc. provided both medical response drones and search and rescue drones to Revived Soldiers Ukraine (RSU), a U.S. nonprofit organization that provides medical and humanitarian aid to Ukraine.

The medical response drones are heavy-duty, multirotor UAVs capable of ensuring the timely delivery of temperature-sensitive medical supplies and life-saving equipment to dangerous and hard-to-reach areas. In June 2022, Draganfly successfully completed deployment and training of its first two situational assessment drones to RSU. Draganfly selected AeroVironment's Quantix Mapper to serve as the situational assessment drone sent to Ukraine; the two companies have an exclusive partnership with regards to selling the Quantix Mapper drone and its related parts and accessories.

The Quantix Mapper is a lightweight, easy-to-operate, fully automated drone with a hybrid vertical takeoff and landing (VTOL) design that allows it to launch vertically and transition to horizonal flight. It can be "quickly deployed for reliable, accurate, and timely information about the battle theater," says Jacobson.

"The situational assessment drones are specifically designed to provide crucial and effective visual oversight during active emergency, medical, and disaster response situations," says Cameron Chell, president and CEO of Draganfly. "The combination of these drones and our first medical response drone will help RSU safely access hotspots and provide humanitarian aid in major Ukrainian cities."

Chell also notes that "the company's situational assessment and medical response drones will help RSU reduce response times, improve situational awareness, and increase overall efficiency as the nonprofit scales up its humanitarian aid operations in Ukraine."

MORE DRONE USES MEAN MORE ENGINEERING JOBS

Experts say the need for qualified mechanical engineers to develop and continue to innovate UAS technology across all industries in the coming years is great, and companies are actively seeking talent with mechanical engineering expertise. As Robbins says, "recruitment of engineers is a top-tier priority for all AUVSI members," which include corporations and professionals working across the defense, civil, and commercial markets.

"We're looking to increase the pipeline of engineers into our field as much as we can. The battle for talent is very fierce," Robbins says.

Today's UAS original equipment manufacturers (OEMs) need mechanical engineers on their teams to design drone prototypes, build and test drone systems, and help bring new drone designs to market. It's no surprise that mechanical engineers who understand concepts like flight dynamics, propulsion, and production methods are attractive job candidates to OEMs.

Resources for Mechanical Engineers

ASME offers a variety of engineering resources to help you stay on top of technical trends and the latest industry advancements. To find more ASME content on drones, visit the Topics & Resources section and search using keyword "drones."

Whether you're an experienced professional or just starting your career, ASME membership can bring value to mechanical engineers across all disciplines (including UAS):

- Use AccessEngineering to assist you with your engineering problems, research, and projects
- Connect with a specialized professional network through ASME's Aerospace Technical Division
- Explore new careers in the drone industry through the ASME Career Center

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Currier observes that mechanical engineering students are often drawn to working on UAS at Embry-Riddle, even though drone technology resides outside the traditional boundaries of that field. "Students get fascinated," he says. Mechanical engineering students with an interest in drones have a straightforward path to work on them by following the university's robotics track and taking classes that involve mechatronics, unmanned systems, and robotic arms, according to Currier.

OEMs are very interested in recruiting not only students and young professionals with a mechanical engineering background, but also veterans with firsthand experience working with drone technology in the field.

Many companies are investing heavily in UAS right now, creating a demand for qualified talent, Robbins says. "I think it's a fun industry for people to be in because it's evolving very rapidly. The technology is moving faster than government regulations can keep up."

The military as well as a wide range of other industries are independently creating an ever-expanding set of UAS use cases that promote the customization of drones and the ongoing evolution of this technology. For example, Robbins describes BNSF Railway's reliance on autonomously operated UAS to inspect railroad tracks and facilities over long distances. "The drones go out on their own, inspect rail lines, send data back, and return," he says. "This saves a human from having to walk the tracks, and it is safer and faster."

This sort of infrastructure inspection is not limited to railways. UAS are used to examine other things such as pipes, bridges, and high-voltage electrical lines, especially in remote or inaccessible regions, eliminating the need for people to perform dangerous or onerous tasks.

Additionally, UAS are being used to gather data, promote safety, and provide other benefits for fields such as:

- Search and rescue operations, to help find missing people
- First response, to provide situational awareness at the scene of a crime or emergency
- Firefighting, for heat mapping, spraying hot spots on a fire, and more
- Agriculture, for surveying farmland, monitoring crops, applying nutrients, and spraying pesticides

Another rapidly growing UAS sector is advanced air mobility (AAM)—considered by some to be the future of on-demand aviation—which will integrate emerging flight technologies into the existing air transportation system to move people and cargo autonomously, once the necessary federal aviation regulations and infrastructure are established. Electric aircraft manufacturers such as Joby Aviation, Lilium, Terrafugia, Volocopter, and others are developing electric vertical takeoff and landing (eVTOL) aircraft powered by hybrid electric systems, batteries, or hydrogen fuel cells.

Whether used for defense, commercial, or civil aviation purposes, UAS technology offers one of the most exciting career opportunities for mechanical engineers right now. "If you can imagine it, then they need somebody to build it," Robbins says. "People are coming up with all kinds of use cases for drones, and this industry is accelerating, not slowing down."

Military Drone Market Forecast

The global military drone market is expected to gain momentum, reaching $26.12 billion by 2028, while exhibiting a compound annual growth rate of 12.78% between 2021 and 2028, according to a 2022 Fortune Business Insights report.

The report noted that as several countries obtain more modern and advanced military drones to enhance their combat capabilities in the coming years, these expenditures are projected to support market growth worldwide. Additionally, "the growing use of [UAV] technologies in the defense sector for several applications such as mapping, surveying, monitoring, transportation, and combat operations will fuel demand for military UAVs in upcoming years."

The Fortune Business Insights report also stated:

- UAS technological advancements have improved the efficiency of military ISR missions.
- Developments in artificial intelligence enable drones to pick combat targets "autonomously with precision and persistence," and AI is also used for autonomous flight systems for high-altitude military UAVs.
- Though the COVID-19 pandemic slowed production and manufacture of drones and negatively impacted supply chains across the globe, "drone technologies have nevertheless witnessed strong growth over the past several years due to the constant innovation and R&D."

Know Your Drones

While the term "drone" refers to any unpiloted vehicle traveling by ground, sea, or air, the aviation industry may use other, more specific terms to refer to them based on their size, design, and usage. Here are a few acronyms to know:



UAM Urban air mobility, a subset of advanced air mobility refers to planned electric vertical takeoff and landing (eVTOL) aircraft usage in the context of high-population urban centers throughout the U.S. In March 2022, the FAA issued draft interim guidance to support the design and operation of facilities that eVTOL will use for their initial operations, and many cities are creating infrastructure to support UAM in the coming years.



UAV In aviation, a drone is considered an unmanned (or uncrewed) aerial vehicle or aircraft, which is operated without the possibility of direct human intervention from within or on the aircraft. These aircraft are categorized by size and range, and they can be guided either remotely by a pilot on the ground or autonomously.



UAS An unmanned aircraft system is defined by the Federal Aviation Administration as "an unmanned aircraft and the equipment necessary for the safe and efficient operation of that aircraft." UAS includes not only the UAV but also the remote pilot controlling the flight and the system that connects them.



AAM Advanced air mobility, which includes the UAM sector, is a rapidly growing field that uses highly automated eVTOL aircraft to transport cargo and people. EVTOL may be either crewed or remotely piloted, but are expected to be increasingly autonomous once government regulations catch up to the technology.

TOP: VOLOCOPTER; LEFT: LiDAR USA; CENTER: AEROVIRONMENT; RIGHT: JOBY AVIATION

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