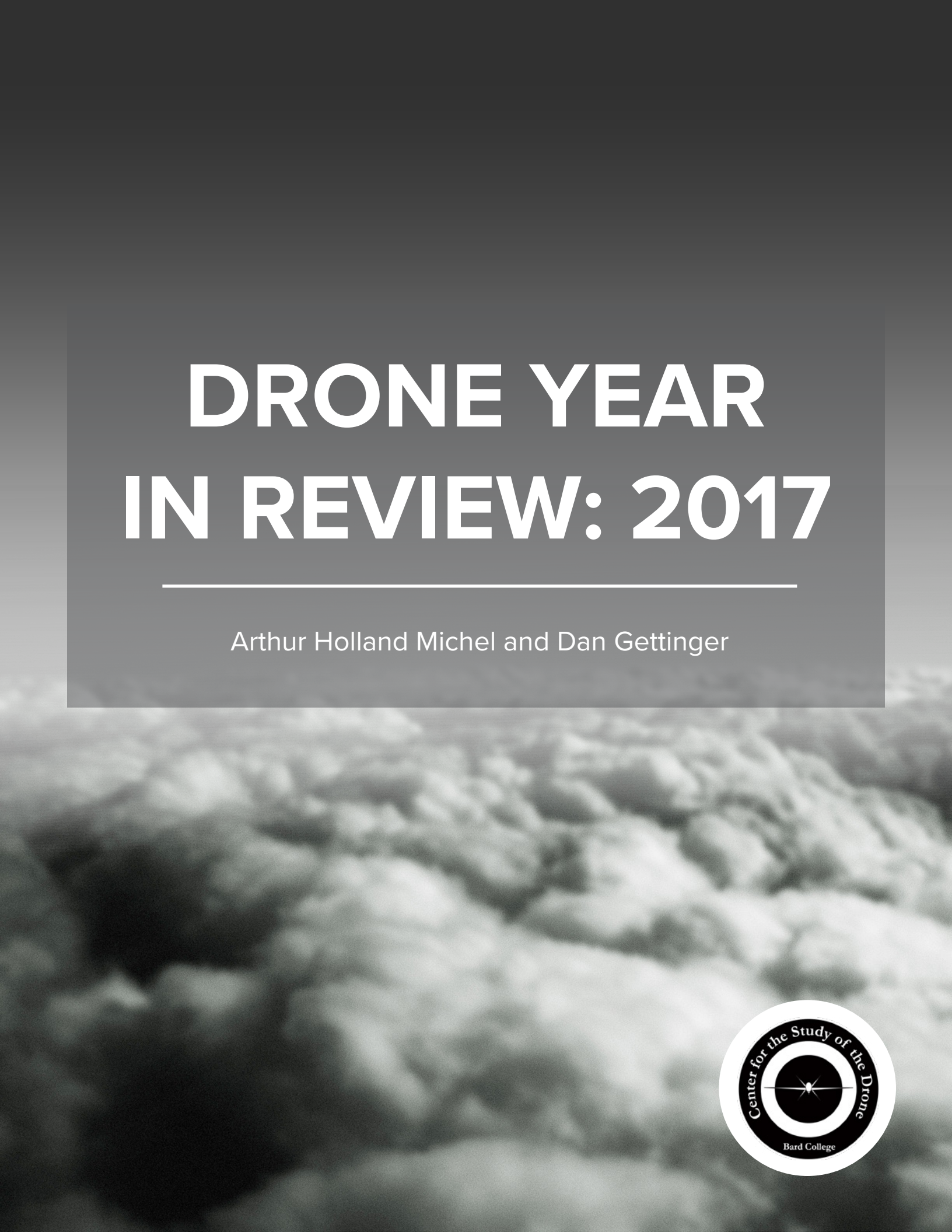
DRONE YEAR IN REVIEW: 2017

Arthur Holland Michel and Dan Gettinger



ABOUT THE CENTER FOR THE STUDY OF THE DRONE

The Center for the Study of the Drone at Bard College is an interdisciplinary research institution that examines the novel and complex opportunities and challenges presented by unmanned systems technologies in both the military and civilian sphere. By conducting original, in-depth, and inquiry-driven projects, we seek to furnish stakeholders, policy-makers, and the public with the resources to engage in a robust public debate and develop policies that best address those opportunities and challenges.

Editorial support provided by Elizabeth Fitzgerald. Presentation by Dan Gettinger.

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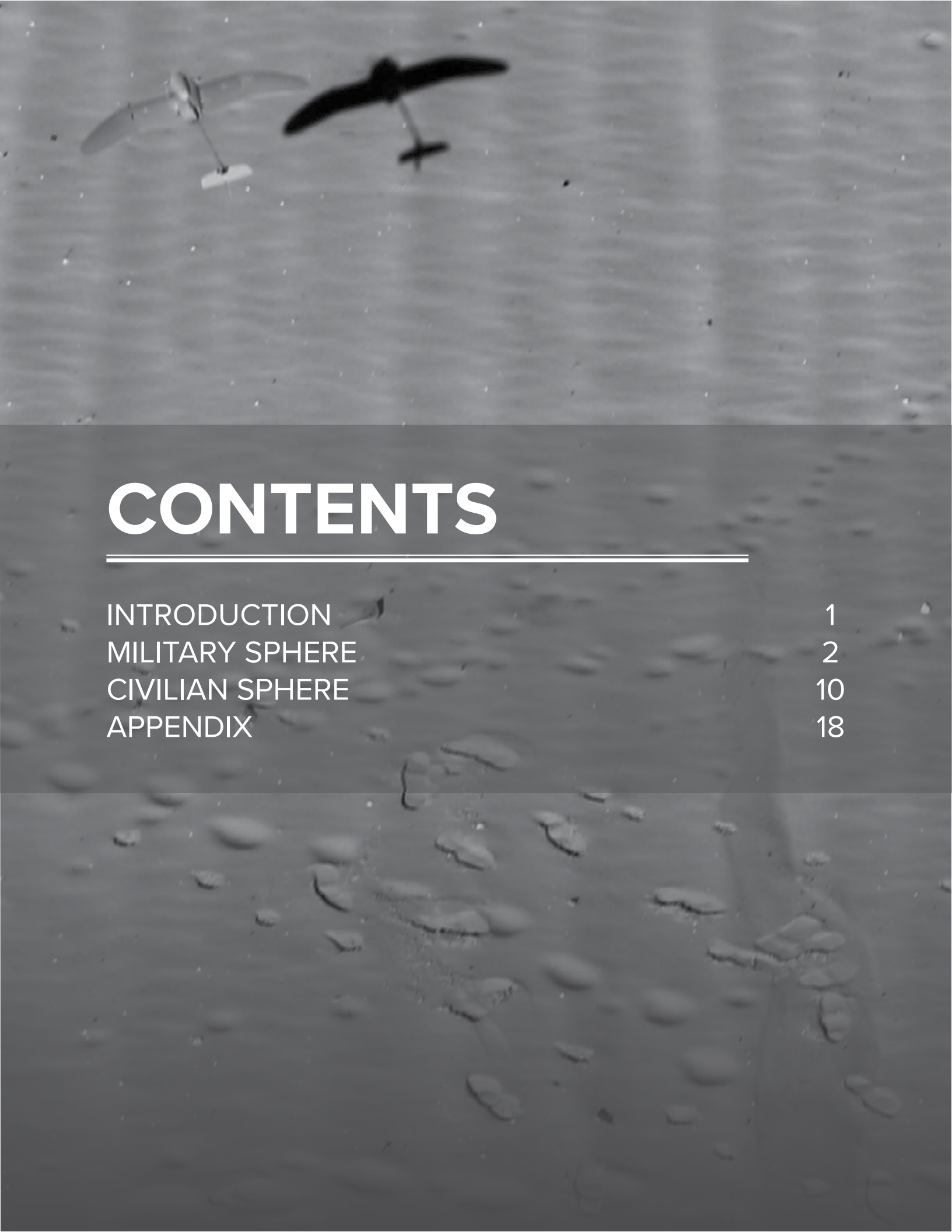

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INTRODUCTION

Like each of the five years since the Center for the Study was founded, 2017 was a busy one in the world of drones. In both the military and civilian spheres, the year saw remarkable technological advances, major deals, expanded regulations, and new debates that will have a profound impact for many years to come. This report documents the most important events and trends that we observed this year, and offers insights into what to expect in 2018 and beyond. The report is divided into two broad sections: one addresses developments in the military sphere while the other considers the civilian sector.

In the military realm, this year saw an uptick in U.S. drone strikes in Yemen and Somalia and a possible loosening of Obama-era targeting guidelines. The global trend in military drone proliferation continued to accelerate, with an ever greater number of shootdowns in conflict zones across the globe. Military research organizations both in the U.S. and elsewhere made significant new breakthroughs in the fields of swarming, long-endurance drones, and jet-powered unmanned systems, and the defense drone industry saw sustained growth and a number of consolidations while it awaits a series of major Pentagon decisions in 2018.

On the civilian side, the Federal Aviation Administration continues to open U.S. skies to drone use, while a range of new countries adopted regulations for small unmanned aircraft. Research groups everywhere, from Switzerland to Singapore, unveiled technological breakthroughs that could have profound implications for future commercial drone technology, including small batlike drones, giant cargo drones, and kits that turn any manned aircraft into a remote control airplane. The consumer drone industry struggled with challenges ranging from stiff competition to privacy and security concerns, though that did not appear to dim the interest of the many venture capital groups that led multi-million funding rounds aimed at launching the next generation of civilian drone systems and applications.

For our part, in 2017 we published a diverse range of publications exploring everything from Amazon's delivery drone patents to the coming year's defense budget. These studies are highlighted throughout this report. We would like to thank our readers for their continued support, and look forward to the challenges, opportunities, and surprises in store for us all in 2018.

MILITARY SPHERE

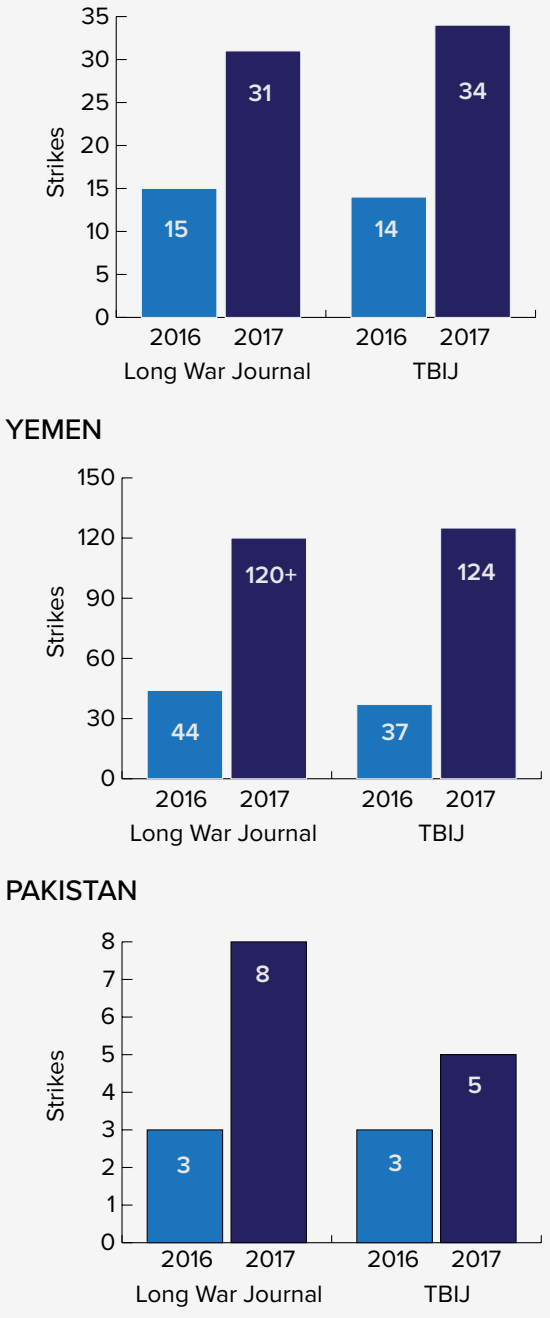
U.S. DRONE STRIKES

This past year was marked by an increase in U.S. airstrikes in Somalia and Yemen and shifts in U.S. policy that could lead to a further expansion of armed U.S. drone activity outside conventional battlefields. In Yemen, according to data collected by the Long War Journal and The Bureau of Investigative Journalism, the U.S. is believed to have launched between 114 and 124 drone strikes, roughly three times as many strikes than in the previous year, which saw somewhere between 32 and 44 strikes. The Bureau has estimated that between 133 and 182 people have been killed in operations in Yemen this year, including at least three civilians. The majority of these strikes targeted members of al-Qaeda in the Arabian Peninsula, an al-Qaeda affiliate that has orchestrated operations against the U.S. in the past.

The U.S. also increased operations in Somalia, launching between 18 and 30 airstrikes in 2017, up from 14 strikes in 2016 and 11 strikes in 2015. The rise in operations comes amidst a deepening U.S. commitment to fight al-Shabab and the Islamic State in the region. Following a request by U.S. Africa Command in March, President Trump relaxed rules for U.S. counterterrorism operations against al-Shabab by declaring parts of Somalia an "area of active hostilities," a designation traditionally used for war zones like Afghanistan and Syria where looser targeting standards apply. Department of Defense officials believe that the U.S. will remain engaged in Somalia for at least two more years, according to a December report by the New York *Times*.

The U.S. is also taking steps to expand drone operations in Niger. Following a failed U.S. special forces raid that resulted in the deaths of American and Nigerien soldiers, the government of Niger granted the U.S. permission to deploy armed drones to the country. (Unarmed U.S. and French MQ-9 Reaper drones have been deployed to Niger since 2013). The drones will initially be deployed to Niamey, Niger's capital, before relocating later in 2018 to

U.S. DRONE STRIKES IN 2017*



**The U.S. also conducted drone strikes in Afghanistan, Syria, and Iraq, which are not represented here.*
Source: The Bureau of Investigative Journalism and The Long War Journal

WEEKLY ROUNDUP

This report is largely based on stories covered over the course of 2017 in the Center for the Study of the Drone's Weekly Roundup of news, commentary, technology, and industry updates. The Roundup was first published in 2013 and remains the most comprehensive weekly newsletter on unmanned systems technology today. Subscribe here to receive the Roundup every Monday in your email inbox.

Agadez, a city in northern Niger where the U.S. is building a new drone base. In Libya, meanwhile, drone operations were more restricted in 2017 than in the previous year, likely because the Obama administration removed Libya from the list of "areas of active hostilities." The U.S. is believed to have launched strikes in Libya on at least three occasions—in September, a flurry of strikes killed at least 17 Islamic State fighters.

U.S. drone strikes in 2017 resulted in the deaths of a number of high level members of militant groups. In February, the U.S. reported killing Abu Hani al-Masri, a founding member of the Egyptian Islamic Jihad and an al-Qaeda leader, in a drone strike in Syria. Also in February, a U.S. drone strike in Syria killed Rachid Kassim, an Islamic State recruiter. In March, a U.S. drone strike in Syria killed Abu al-Khayr al-Masri, a senior leader in al-Qaeda. Also in March, a U.S. drone strike in Afghanistan killed Qari Yasin, the planner of a 2008 bomb attack on the Marriott Hotel in Islamabad. In July, a U.S. drone strike in Afghanistan killed Abu Sayed, the leader of the Islamic State in Afghanistan. In July, a suspected U.S. drone strike in Somalia killed Ali Muhammad Hussein, an al-Shabab leader.

Drone Strike Policy Changes

The first drone strike in the Trump administration occurred on January 20—inauguration day—in Yemen. In the following months, the Trump administration walked back some of the policy guidelines for drone strikes and special forces raids established by President Obama. The administration's policies now reportedly permit the military and the CIA to target low-level militants and to launch strikes without the approval of a high-ranking U.S. official. The administration retained a requirement aimed at limiting civilian deaths and the separation of geographic areas between "areas of active hostilities" such as Afghanistan and Somalia, and "areas outside of active hostilities," such as Yemen and Pakistan, where stricter rules for strikes apply. Still, it remains to be seen how these policy changes will be implemented; following the Trump administration's decision to declare Somalia an "area of active hostilities," U.S. military commanders decided to keep in place the constraints that were technically waived following the re-designation.

Looking Forward:

For the most part, President Trump has continued and, in some cases, escalated the counter-terrorism missions left to him by his predecessor. However, as we head into the new year, some key questions regarding U.S. drone operations outside of conventional battlefields remain open. For example, it is still unclear whether the Trump administration has followed through on a proposal to grant the CIA more authority to launch drone strikes. The coming year could yield new details about the Trump administration's revised guidelines for drone strikes outside of conventional battlefields. (In December, the American Civil Liberties Union filed a lawsuit to compel the administration to release the text of the policy.) As of the passage of the 2018 National Defense Authorization Act, the Trump administration is required to publish an update to the Obama administration's 2016 report on U.S. counterterrorism operations outside of conventional battlefields. This report should include updated information regarding U.S. drone operations and is expected in early 2018. We expect drone operations to increase in west Africa following the opening of the U.S. drone base in Agadez, Niger in mid-to-late 2018.

Photo by Senior Airman Chase Cannon/U.S. Air Force

DRONE DEVELOPMENT

Swarms and Micro Drones

This year saw major advances in the increasingly significant pivot toward small, low-cost systems, in some cases configured for air-launch and swarming. In January, the Pentagon announced that its Strategic Capabilities Office had carried out a test the previous year in which over 100 Perdix micro-drones launched from F/A-18 fighter jets flew in a coordinated swarm. Later in the year, the same team at MIT that designed the Perdix announced that it is developing a fighter-launched drone called the Firefly that can travel at speeds of up to Mach 0.8 (though fast for a drone, this is still just a snail's pace compared to the Mach 5 hypersonic drones that the Air Force announced that it wants to deploy by 2040). The U.S. Defense Advanced Research Projects Agency (DARPA) began studying the feasibility of building an inexpensive drone armed with air-to-air missiles that can be launched from the wing of a jet fighter while also exploring, in a separate initiative, the idea of exploiting video game technologies for controlling swarms of drones.

The Air Force Research Laboratory is likewise developing small unmanned aircraft that can be launched from AC-130 gunships or similar manned aircraft. Looking to a healthy future market for airplane-launched drones, Northrop Grumman and VX Aerospace are developing an unsolicited canister-launched system that could be mounted on the Navy's E/A-18G Growler manned jet. Some of the air-launched drone efforts that emerged are focused on a specific and perhaps unexpected mission: resupplying forces in the field. DARPA began work on glider drones that can drop urgent medical supplies and then disintegrate once they complete their mission. By the year's end, one of the contractors in the effort, DZYNE, had begun flight testing one vanishing prototype, while a second company continued development of a system made from a polymer that disappears when exposed to sunlight. Meanwhile, the U.S. Marine Corps announced that it is developing disposable plywood glider drones that can be launched from a KC-130 transport. These low-cost aerial mules will be capable of delivering 700 pounds of cargo at distances of up to 70 miles.

In other developments, the U.S. Army issued a request for information for small reconnaissance drones that could be used by individual soldiers, while Prox Dynamics and AeroVironment both unveiled new nano drones, and researchers at the Charles Stark Draper Laboratory and Howard Hughes Medical Institute created a system that turns live dragonflies into steerable drones. Beyond the U.S., the China Electronics Technology Group Corporation conducted a flight test of a swarm of 119 small drones, and the Russian military is reportedly developing an artillery-launched small unmanned aircraft that could potentially be used in swarm configurations.

Jet-Powered Drones

On the opposite end of the size and cost spectrum, a new generation of futuristic jet drones continues to evolve. The U.S. Navy issued its final request for proposals detailing the specifications of its planned MQ-25A Stingray carrier-based drone, which will have much reduced intelligence, surveillance, reconnaissance, and strike capabilities compared to the initial concept for the program. U.S. drone maker Kratos made progress in the development and testing of two new "low-cost" combat drones, the XQ-222 Valkyrie and the UTAP-22 Mako, the latter of which successfully completed a series of complex multi-drone tests as part of the Air Force's Loyal Wingman program. British defense firm BAE unveiled a jet-powered drone called MAGMA that is steered using diverted jet air that exits its trailing edges. In Turkey, defense firm Baykar Makina

The Kratos UTAP-22. Photo by Kratos.

announced that it is planning to develop a large jet-powered military drone.

Endurance

Along with the pursuit of speed, military organizations also pushed the bounds of endurance for unmanned aircraft. DARPA and U.S. firm Vanilla Aircraft completed a 121-hour test flight of the diesel-powered VA001 drone, a new record. The U.S. Air Force is revisiting the possibility of developing a surveillance and reconnaissance drone that can fly for a week without refueling, while U.S. aerospace firm Aurora Flight Sciences, which was acquired by Boeing, looks to build an improved version of the Orion high-altitude, long-endurance drone (an aircraft that began life as an Air Force project, it could potentially fly for weeks on end). The U.S. Naval Research Laboratory is working to develop solar-powered unmanned aircraft that can remain aloft for extended periods, as well as a fuel cell-powered drone called Hybrid Tiger that could have an endurance of up to three days. Meanwhile, at MIT, a team of researchers has developed a small low-cost gas powered drone that can remain airborne for up to five days at a time.

Endurance isn't just improving in the air. Marine unmanned systems maker ASV Global unveiled a 12-meter unmanned boat, the C-Worker 12P, optimized for long endurance operations. Singapore-based firm Zycraft announced that its Independent USV completed a test in which it was deployed in the South China Sea for a continuous period of 22 days, while the China Aerospace Science and Technology Corporation announced an effort to build a large autonomous unmanned surface vehicle with a range of up to 540 nautical miles. (China's interest in unmanned boats of all kinds is reaching fever pitch; it also unveiled an armed high-speed unmanned surface vehicle, the Tianxing-1).

Cross-Domain

Significant breakthroughs were also achieved in technologies to achieve collaboration between drones in different domains. In a demonstration at a U.S. Navy exercise, defense firm General Dynamics launched an aerial drone from an unmanned undersea vehicle. Northrop Grumman conducted a simulated seabed warfare mission with two unmanned surface vehicles, three unmanned undersea vehicles, and a manned helicopter representing an aerial drone. Defense firm Lockheed Martin unveiled the Outrider, a small submarine-launched surveillance drone, which the U.K. is hoping to deploy to search for adversary submarines. Meanwhile, in a test of its own, the U.S. Army Research, Development and Engineering Command, the Tank Automotive Research Development Engineering Center, and the Army Research Lab operated an Abrams tank in conjunction with drones and an unmanned Humvee.

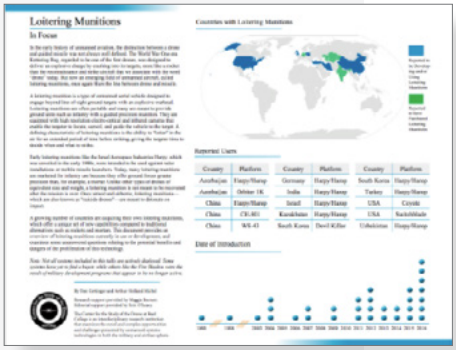
Looking Forward:

In 2018, we expect to see major breakthroughs in miniaturized drone technologies, including advances in high performance sensor systems that are small enough to fit on tactical drones (for example, the U.S. Army announced in 2017 a major new initiative to develop a next-generation tactical drone); further development in manned-unmanned teaming programs in the Air Force, the Navy, and the Army; new announcements about ongoing U.S. efforts to produce jet-powered strike drones capable of operating in denied airspace (most of which remain classified); numerous new indigenous armed drone development programs in countries across the globe; and a renewed interest in ultra-long-endurance high-altitude drones, sometimes also referred to as pseudo-satellites.

For a list of new military drones that were unveiled in 2017, see Appendix page 20.

LOITERING MUNITIONS

A loitering munition is an explosive-laden drone designed to fly over the battlefield for extended periods before engaging ground targets like a missile. In recent years, this technology has been proliferating rapidly, raising a host of ethical and legal questions that have as yet remained largely unaddressed by the international community. "Loitering Munitions in Focus" is a one-stop primer on how this technology works, what it looks like, who is using it, and what its implications are. The study includes a database of 31 types of loitering munition currently in production around the world.



INDUSTRY

One of the biggest defense drone industry stories to emerge from 2017 was Boeing's acquisition of Aurora Flight Sciences. In recent years, Aurora has played a key role in some of the most advanced drone development programs, winning $81 million in FY 2015 and FY 2016 in drone-related DARPA efforts such as the VTOL X-Plane program. The company represents a considerable addition to Boeing's capabilities in the field of unmanned and autonomous technology. Other consolidations in the industry included Boeing's acquisition of Near Earth Autonomy, a Pennsylvania-based firm that develops autonomous capabilities for drones, and L3 Technologies' acquisition of OceanServer Technology, a provider of small unmanned undersea vehicles.

The Department of Defense made progress on some key drone programs. In what was perhaps the largest single drone contract of the year, the U.S. Air Force awarded General Atomics Aeronautical Systems a nearly $400 million contract for 36 MQ-9 Reaper aircraft. On the ground, the U.S. Army awarded Endeavor Robotics a $159 million contract for over 1,200 Man Transportable Robotic System Increment II bomb-disposal robots. And in the sea, the U.S. Navy awarded Boeing and Lockheed Martin over $85 million in contracts to build prototypes of the Orca Extra Large Unmanned Undersea Vehicle (XLUUV). Although competition to build the next generation of drones is intense, one surprise of the year occurred in October when Northrop Grumman pulled out of the competition to build the Navy's MQ-25 Stingray refueler drone. Northrop Grumman was responsible for building the X-47B, a demonstrator aircraft that preceded the MQ-25.

The past year saw a flurry of contracts for counter-drone systems. Syracuse Research Corp. in New York emerged as an early leader in the field, snagging a $65 million Air Force contract for 15 systems in January. The Army, meanwhile, awarded Leonardo DRS a contract worth up to $42 million for a vehicle-borne C-UAS capability in October. In April, DIUx, the Pentagon's innovation cell, invested in at least two counter-drone startups, SkySafe and Sensofusion. Globally, interest in systems to counter all types of drones is on the rise. Rheinmetall AG won contracts to install drone detection systems at prisons in Switzerland. The Spanish military awarded Blighter a contract for the AUDS counter-drone system, which was slated to be deployed almost immediately. Paraguay is reportedly engaged in an effort to find a system capable of intercepting Brazilian military drones that stray over the border without authorization.

Looking Forward:

The coming year will see some important decisions that will impact the future of drones. The Navy expects to announce the winner of the competition to build the MQ-25 Stingray by late summer 2018, while the Army is expected to pick a drone for the Soldier Borne Sensor, a program intended to outfit soldiers with small, portable drones. Throughout 2018, the Army will also test several proposed versions of the Squad Multipurpose Equipment Transport (SMET), a robot intended to lighten the load of soldiers. The Navy's Orca XLUUV program is set for an important design review that will determine which company's prototype moves to the next level. The Pentagon will also likely release a new 25-year roadmap outlining plans for drone modernization, acquisitions, and missions—a much-anticipated update of the 2013 "Unmanned Systems Integrated Roadmap."

DRONE BUDGET

In our report, "Drones in the Defense Budget: Navigating the Fiscal Year 2018 Budget Request," we found a 20 percent increase in planned drone spending in Fiscal Year 2018, nearing a total of $7 billion. The report found that drone-related spending overall is significantly higher than previously predicted, though spending on unmanned aircraft has decreased in recent years as a proportion of DoD spending on drones across all domains. The report is based on five years of DoD budget data and over 400 drone-related line items.

PROLIFERATION

Many of the trends in drone proliferation that emerged in 2016 continued in 2017. China pursued international customers for its strike-capable drones, while various countries launched or expanded their own programs to develop or acquire drones. Meanwhile, non-state actors continued to modify and deploy small armed drones, raising fresh concerns that these systems might be used to attack civilian targets.

China continued to push exports of its medium-altitude long-endurance unmanned systems in 2017. In March, Chinese media reported that the country would construct a factory in Saudi Arabia to produce Caihong-series (CH) surveillance and strike drones. China also revealed that it had made its largest sale ever of the Wing Loong II, another strike-capable drone, to an unnamed customer in the Middle East. In December, it was reported that China had successfully delivered new CH-5 drones to Egypt, which is believed to already operate the Wing Loong. While these reports have yet to be confirmed by outlets outside of China, they are in line with a pattern of growth in Chinese drone exports over the past several years. In the coming year, we expect additional deliveries of Chinese drones to global customers. New Chinese drones unveiled in 2017 like the medium-altitude long-endurance Tengoen TB001 and Beihang TYW-1, the AT200 cargo drone, and the AVIC AV500W rotary drone, could soon follow the Caihong and Wing Loong drones into the international market.

Other countries took steps to acquire or upgrade their own drones. In June, Canada announced that it will acquire a variety of unmanned systems—including armed drones—for its military. France, meanwhile, has opted to arm its fleet of MQ-9 Reapers, becoming the third country after Italy and the U.K. to fly armed U.S.-made drones. At the MAKS 2017 airshow, Russia unveiled the Kronshtadt Orion-EH, a medium-altitude long-endurance drone that has been under development since 2011 that could eventually be armed. Kazakhstan displayed a host of drones at its May 7 military parade, including Russian-made Orlan-10 reconnaissance drones and a Wing Loong. The Turkish military took delivery of additional Kale-Baykar Bayraktar TB-2 drones, a mid-sized unmanned aircraft that can be armed with mini smart munitions. South Korea announced plans to establish a military unit dedicated to fielding swarms of drones and the Czech Republic announced plans to dramatically expand military unmanned aircraft procurement with the goal of acquiring a strike-capable system by 2021.

An Iranian-made Ababil-2 target drone displayed at Joint Base Anacostia-Bolling on December 12, 2017 as evidence of Iran's involvement in the war in Yemen. Photo by EJ Hersom/DoD.

Drone use by non-state actors also expanded dramatically in 2017. In an analysis of documents captured from the Islamic State, the Combating Terrorism Center at West Point found that ISIS had a formalized system for managing drone operations. In September, U.S. airstrikes targeted Junaid ur Rehman, Abu Salman, Abu Muadh al-Tunisi, and Sajid Farooq Babar—four militants who, according to U.S. Central Command, helped lead the ISIS drone program. Meanwhile, in Yemen, Houthi rebels unveiled a series of drones that appeared to be inspired by Iranian systems. According to a report by the Conflict Armament Research group, one of these drones was used to attack Saudi air defenses. Elsewhere, other groups appeared to be adapting consumer drones for their own goals. In Mexico, authorities found a drone that was carrying a shrapnel-filled

"We do know that terrorist organizations have an interest in using drones. We have seen that overseas already with some frequency. I think that the expectation is that it is coming here, imminently."

FBI Director Christopher Wray, September 27, 2017

improvised explosive device. In the Philippines, authorities captured a militant who admitted to operating a drone during the attack on Piagapo city for the Maute group, a now-defunct terrorist group that was affiliated with ISIS. The rise in these incidents has inspired concerns about the use of drones to attack civilian targets. To prepare for the 2018 Winter Olympics, South Korean police simulated a drone attack on a stadium, and have assured outlets that they are prepared to address a potential attack.

There were times during the past year when the proliferation of unmanned systems appeared to contribute to rising tensions between countries. In June, U.S. forces shot down two Iranian Shahed-129 strike-capable drones in Syria after they appeared to threaten U.S.-backed allies. A few weeks later, Iranian drones interfered with U.S. Navy operations in the Persian Gulf with one drone coming within 100 feet of a Navy jet. In response to complaints by U.S. Navy officials, Iran simply promised to continue its drone patrols in the Gulf. Meanwhile, in the months following a scuffle between Indian and Chinese border guards over Chinese construction in the disputed region around the Doklam Plateau, both countries deployed drones to bases nearby. China has deployed several new Xianglong "Soar Dragon" high-altitude long-endurance drones and a CH-4 strike-capable drone to Shigatse Airport, and a BZK-005 surveillance drone to Lhasa Gonggar Airport, while India appears to have based a drone at Bagdogra Airport. In December, an Indian IAI Heron surveillance drone crashed on China's side of the disputed border after a reported technical malfunction, leading China to file a complaint with India's foreign ministry.

Looking Forward:

In the coming year it is likely that, as Chinese exports and indigenous development programs around the world continue to expand, the U.S. will make a more aggressive effort to market unarmed U.S.-made drones overseas. In mid-2017, the Trump administration began a review of U.S. drone export policies implemented by the Obama administration. In October, Reuters reported that the administration was close to completing an update to the policy, which is expected to loosen restrictions on U.S. drone exports and enable U.S. companies to sell surveillance drones like the MQ-9B Sky Guardian to customers other than NATO partners. In addition to resetting domestic policy, the U.S. may also push to renegotiate the Missile Technology Control Regime, a 1987 international agreement that established limits on missile and unmanned systems sales. Less clear, however, is whether the U.S. will continue to lead an effort to create international standards on drone exports or if such an agreement would be feasible without U.S. participation. Little in the way of concrete progress has been reported on this effort since it was announced in October 2016 and, in the coming year, many are hoping that this effort will gain traction inside the Trump administration and with the international community, though it is not seen as a high-priority item on the White House agenda.

DOWNED DRONES

- **January 16**: Iran reports shooting down an unidentified drone flying over Tehran, the capital.
- **February 23**: Israel reports shooting down a drone flying from the Gaza Strip.
- **March 4**: Armenian separatists in the Nagorno-Karabakh region report shooting down one of Azerbaijan's Orbiter drones.
- **April 27**: Israel reports shooting down a Syrian surveillance drone over the Golan Heights.
- **May 11**: Jordan reports shooting down a drone on its border with Syria.
- **June 9:** The U.S. reports shooting down an Iranian-made Shahed-129 drone in Syria.
- **June 20**: The U.S. reports downing a second Iranian-made Shahed-129 drone in Syria.
- **June 21:** Pakistan reports shooting down an Iranian drone in west Balochistan province.
- **June 22**: Azerbaijan reports shooting down an Armenian drone near Terter.
- **September 19**: Israel reports shooting down a drone over the Golan Heights. The drone was suspected to be Iranian-made and operated by Lebanon's Hezbollah militant group.
- **October 2**: Houthi rebels claim to have shot down a U.S. drone in Yemen. The U.S. military says that the incident is under investigation.
- **October 27**: Pakistan reports shooting down an Indian military DJI Phantom drone.
- **November 11**: Israel reports shooting down a Russian-made Syrian surveillance drone over the Golan Heights.
- **December 25**: Azerbaijan reports shooting down an Armenian drone made by DJI.
- **December 28**: Ukraine reports shooting down a Russian-made Orlan-10 drone.

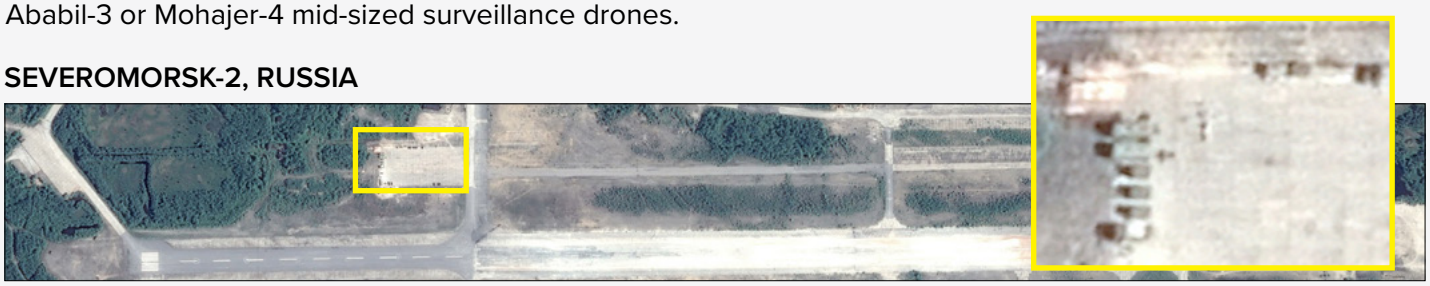
DRONE BASES

As more countries acquire drones, these systems are beginning to appear at air force bases around the world—sometimes in surprising places—with increasing frequency. Here are a few notable drone deployments that were discovered in 2017

MARJAN, IRAN

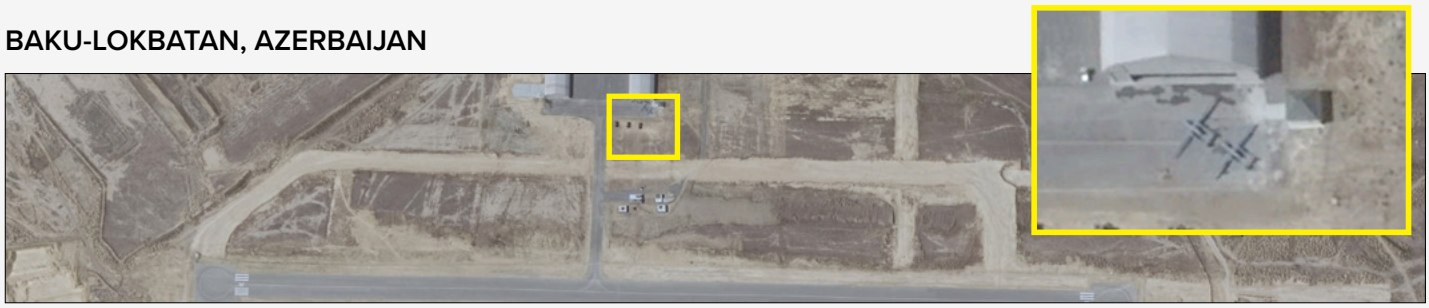
A June 19, 2017 satellite image shows multiple unmanned aircraft and a collection of support vehicles temporarily deployed to airstrip outside the town of Marjan, which lies on the Iran-Iraq border. The aircraft are likely Ababil-3 or Mohajer-4 mid-sized surveillance drones.

SEVEROMORSK-2, RUSSIA



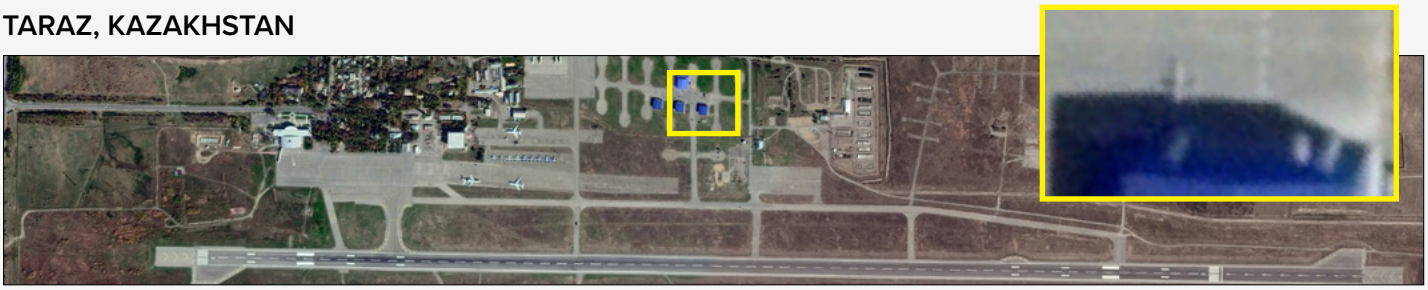
A July 25, 2017 satellite image shows that Russia has deployed at least one Forpost mid-size surveillance and reconnaissance drone to Severomorsk, the home to Russia's Northern Fleet. According to a report in Russian media, the deployment is part of a much delayed push to equip Russian fleets with drone capabilities.

BAKU-LOKBATAN, AZERBAIJAN



A September 16, 2017 satellite image of an air base west of Baku, Azerbaijan shows two Israeli-made IAI Heron drones and support equipment. The base, which was completed sometime in mid-to-late 2016, is likely a new training facility and support base for Azerbaijan's growing fleet of drones.

TARAZ, KAZAKHSTAN



An October 17, 2017 satellite image of Taraz Air Base in Kazakhstan shows a mid-sized surveillance drone. Earlier in the year, Kazakhstan established a drone training facility at Taraz. While the model of the drone is not clear, it could be a Belorussian Grif-K.

Images by Google Earth

CIVILIAN SPHERE

REGULATIONS

The Federal Aviation Administration continued to take steps toward further integration of drones in the U.S. national airspace system. Under its Part 107 waiver program, it granted 1,169 permissions to entities for drone operations that would have been prohibited under the regular rules. For example, in Georgia, 3D Robotics received permission to operate a drone at Hartsfield-Jackson Atlanta International Airport, the first waiver for drone operations at such a busy air hub. In Texas, the FAA authorized 43 drone operators to conduct flights for emergency response and recovery operations and newsgathering following Hurricane Harvey after initially issuing a blanket ban on all private drone operations in the area. Shortly thereafter, it granted CNN permission to fly drones over people. It is also taking steps to open the skies to large unmanned aircraft. In one FAA-approved test, General Atomics Aeronautical Systems flew a Predator B drone 1,075 nautical miles from a facility in Grand Forks, North Dakota, the longest flight of a large drone in civilian Class A airspace. To further streamline its permissions process, the agency released over 400 maps showing airports where it is able to authorize drone operations without a one-off safety analysis, and developed a system that will automate low-altitude drone operation authorizations, which it has already activated at a few dozen airports around the country and plans to unveil nationwide in 2018. In a bid to accelerate the integration process in the coming years, the Trump administration also unveiled a pilot program that would allow five or more local, state, and tribal governments to establish "innovation zones," in partnerships with private firms, where they can test complex drone operations, including nighttime flights, beyond line-of-sight operations, and flights over people. The Department of Transportation intends to use the results of these tests to inform future regulations.

U.S. CIVILIAN DRONES AT A GLANCE*

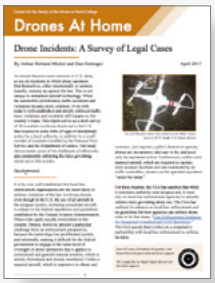
Hobbyist Users	836,796
Non-Hobbyist Drones	106,739
Certified Remote Pilots	69,166
Part 107 Waivers Granted	1,448
UASIPP Applicants	2,833

*Based on the latest available information as of publication.

Enforcement

On the enforcement side of the integration equation, U.S. federal government and local law enforcement authorities doubled down on efforts to bar unsafe or illegal drone operations. The federal government granted 133 military installations around the country permission to shoot down drones that venture into their airspace, and banned drones from operating over seven Department of Energy nuclear

DRONE INCIDENTS



These cases and several dozen others are compiled and analyzed in our report on legal cases involving drones, "Drone Incidents: A Survey of Legal Cases." The survey, which considered incidents in five separate categories, revealed a high degree of variance in the way that similar incidents are prosecuted by different enforcement authorities, pointing to the significant challenge that the federal government faces in its bid to create a national uniform, enforceable airspace system.

LOCAL LAWS

In March, we identified over 130 U.S. cities that have adopted local drone laws restricting everything from the use of drones over private property to operating drones under the influence of drugs or alcohol. Many of these ordinances appear to contravene federal authority.

research facilities. The FAA is looking to potentially fine a Brooklyn man who crashed his drone into an Army helicopter in New York after a National Transportation Safety Board investigation found that he was operating beyond visual line-of-sight in restricted airspace at the time of the incident. The Seattle Municipal Court sentenced a man whose drone injured two people at a parade in 2015 to 30 days in jail, while a man in Orem, Utah was sentenced to 160 days of jail for using a drone to spy on residents in the town. Several states passed laws banning drone use near or over correctional institutions. (See "Drone Incidents" on previous page).

Local Laws

An additional challenge to the FAA's efforts to implement a single, unified federal regulatory regime for drones is the proliferation of local drone laws. As the number of drones has grown in recent years, resulting in a spike in drone-related incidents, many communities in the U.S. have opted to take matters into their own hands, implementing local ordinances to supplement federal drone regulations. In September, in the first ruling of its kind, a U.S. federal judge declared some aspects of one such ordinance in Newton, Massachusetts to be invalid, finding that they impinge on the Federal Aviation Administration's authority to regulate the airspace. Similar legal challenges, which pit the federal government's rights against the rights of local authorities to control their airspace, are likely to follow. We have already observed that a number of localities that have become aware of the issue have either revised or rescinded local ordinances so as to avoid conflict with federal regulations. In an effort to address the issue, the FAA has devised an initiative aimed at improving the coordination of drone regulations between federal, state, and municipal authorities, splitting control of the airspace below 400 feet between federal and local governments.

Registration Program in Flux

In May, not long after the FAA announced that over 700,000 drone users had registered with the agency under its registration requirement for hobbyists and non-recreational drone operators, a U.S. Court of Appeals struck down the registration requirement for hobbyists. The court ruled that the registration system violates the 2012 FAA Modernization and Reform Act, which does not grant the FAA the authority to regulate model aircraft. But in December, the government reinstated the rule through a provision included in the 2018 National Defense Authorization Act, just in time for the Christmas surge in new drone operators.

Abroad

Beyond the U.S., numerous countries have adopted or evolved their own national drone regulations. European Union lawmakers and members states agreed on a tentative plan to overhaul the EU's aviation safety regulations, including new standardized rules for drone users, which are currently established individually by each member state. Among other provisions, the deal would require that users register all drones above certain size, weight, and speed thresholds. Meanwhile, the International Civil Aviation Organization announced that it plans to develop global standards for small unmanned aircraft traffic management, along with a single global drone registry. The U.K. Department of Transport is developing regulations that would implement a

DRONE REGISTRATIONS

As of October 31, over 900,000 drone users and drones have been registered with the FAA. The Center for the Study of the Drone published the first analysis of this most recent set of registration data, which the FAA released in November. We found that non-hobbyist drone registrations have accelerated in 2017, while hobbyist registrations slowed; states with low population densities are more likely to have high rates of non-hobbyist drone registrations; DJI products account for at least 70 percent of all registered non-hobbyist drones; and one company, probably Intel, has singlehandedly skewed the data by registering nearly 7,000 light show drones in a zip code in California.

drone registration program, safety courses for drone owners, and more extensive geo-fencing to keep drones out of restricted areas, as well as grant police the authority to seize drones that are deemed to be operating illegally.

Canada announced new rules for recreational drone users, including a flight ceiling of 295 feet and a prohibition against flying near airports. Kenya's government implemented regulations for commercial drone use and now allows companies to import drones for a range of operations. India's Directorate General of Civil Aviation unveiled draft regulations for small unmanned aircraft systems that would require that individuals wishing to use drones weighing over two kilograms obtain a security clearance, a permit, an identification number, and a remote pilot license. After several near-miss incidents in its airspace, Portugal announced that it would accelerate the implementation of a new law under which drone owners would need to register and purchase insurance. Israel granted drone maker Airobotics approval to fly drones autonomously, the first such permission in the country. Meanwhile, Iran banned private drones from Tehran's airspace after a number of incidents in which the city's air defense systems engaged suspicious unmanned aircraft.

Looking Forward:

In the U.S., 2018 is likely to see the publication of new rules governing micro-drones under a certain weight threshold, rules that better define the limits of local authorities' rights to regulate drone use, an automatic approvals system for otherwise restricted drone operations, and significant advances in NASA's unmanned aircraft air traffic management program (which will be transferred to the FAA in 2019). Abroad, we expect to see new regulations published or implemented in several more countries. The EU's Union-wide regulations must be approved by each member state's national government, so while we can expect progress on the initiative, it is unlikely that these regulations will be implemented before the end of 2018. We expect to observe the implementation of elements of air traffic control for drones in countries that are more advanced in the drone integration arc, such as Israel. We can also expect to see the trend in local drone laws expanding beyond U.S. borders; for example, in Australia, the city of Ballarat passed a local law that requires drone operators to obtain a permit before flying drones over municipal property or roads.

DRONE TECHNOLOGY

A diverse range of universities, established technology firms, and startups made breakthroughs this year that may have profound implications for the civilian drone sphere:

- Researchers from CalTech and the University of Illinois Urbana-Champaign created a small unmanned aircraft that flies like a bat, potentially opening the way for unmanned aircraft that are lighter, quieter, and have a longer endurance.
- Israeli firm GPSdome developed a jam-resistant GPS system that could make drones impervious to certain counter-drone weapons and hacking attacks (DARPA and MIT are working on a similar initiative).
- Researchers at the Swiss Federal Institute of Technology and Zurich University of the Arts developed a hexacopter with independently rotating propellers that is capable of flying in far more acrobatic ways than traditional multirotor drones.
- A team at the Singapore University of Technology & Design built a vertical take-off drone that transitions to horizontal flight by turning its rotors into wings, a new approach to the problem of how to build fast, fixed-wing drones that take off vertically.
- Energy firm twingtec revealed its plans for a tethered drone that harvests power from the wind. Wind-collection drones would be much lighter and cheaper than traditional wind turbines, and because they are portable, they could potentially be used to create temporary wind farms in disaster areas. European utility E.ON is investing in a similar concept for offshore wind farms.

Others pushed the limits of what had previously been possible with existing drone technology, breaking records for endurance, range, and carrying capacity.

- A team from Johns Hopkins University successfully transported a temperature-controlled medical sample over 160 miles by drone.
- A Skyfront Tailwind hybrid multirotor drone flew for four hours and 34 minutes, a new unofficial record, while researchers from the Autonomous Systems Laboratory and ETH Zurich are working on a solar-powered drone capable of long-endurance operations.
- U.S. drone maker UAVOS developed a kit that can convert manned aircraft into drones that can carry far more than that. As with the military sphere, there is growing interest in civilian cargo drones; Nautilus, a California startup, is developing a drone that could carry thousands of pounds of goods over long distances, while California Startup Elroy Air secured $4.6 million in seed funding to develop an autonomous drone capable of carrying 150 pounds up to 300 miles.

Safety Breakthroughs

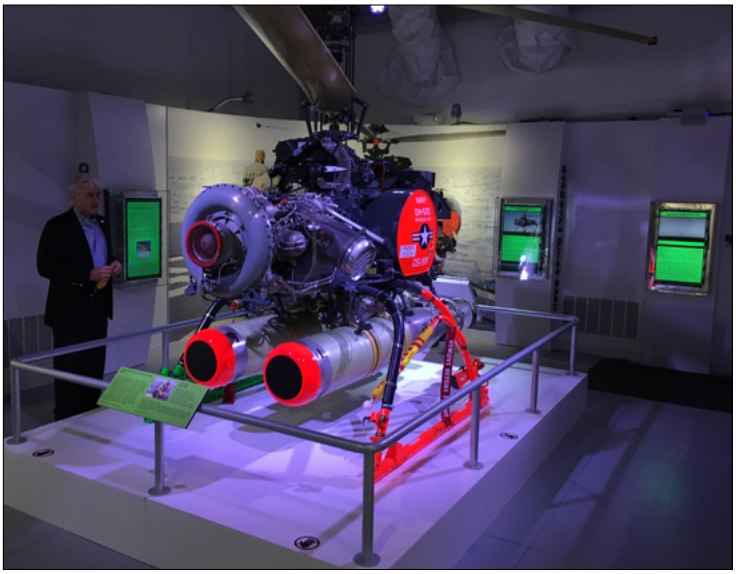
Close encounters between drones and manned aircraft remain common, and though the small number of collisions that occurred this year did not result in catastrophic accidents, an FAA-sponsored report found that drones could inflict more damage than birds in collisions with manned aircraft. A number of efforts seek to address this issue. For instance, the FAA has taken a keen interest in the concept of electronic identification technologies, by which drones broadcast an "electronic number plate" to receivers on the ground. In December, a U.S. federal advisory committee recommended that the FAA implement an electronic ID system to track drones in flight and identify suspicious or dangerous activity in the air. Earlier in the year, Chinese dronemaker DJI unveiled one such electronic identification and monitoring system, which is already being tested at several airports and other facilities. As part of its ongoing work to develop air traffic management systems for drones, NASA conducted successful beyond-visual-line-of-sight tests of a sense-and-avoid system for small drones and tested five drones in a number of complex scenarios. Meanwhile, various

NEW APPLICATIONS

Beyond technological advances, this year also saw a wide range of new applications for unmanned systems technology.

- Telecom firm AT&T used LTE-equipped drones to provide temporary cellular service in Puerto Rico.
- A power company in Xiangyang, China used a flamethrower-equipped drone to burn garbage stuck to power lines.
- Drone maker Flyability used a collision-resistant Elios drone to inspect the interior of a nuclear reactor building.
- Researchers from Cornell University deployed drones to measure landscape surface reflectivity as a means of studying climate change.
- A team of researchers from Oklahoma State University and the University of Nebraska used drones to study atmospheric conditions during the solar eclipse.
- A team of researchers from the Amazonas State University began monitoring the health of forests in the Amazon by flying drones that can sense gases emitted by trees.
- The Japan Agency for Marine–Earth Science Technology deployed a Wave Glider unmanned submarine to provide early warnings of tsunamis near the Ogasawara archipelago.
- Norwegian firm Beck Engineering developed an unmanned undersea vehicle that kills salmon lice in fish farms, and non-profit Robots in Service of the Environment has developed an unmanned undersea vehicle that stuns and captures invasive lionfish.

In the wake of multiple significant hurricane events in 2017, drones emerged as critical tools for infrastructure and building inspections. After Hurricane Maria, the New York Department of Environmental Conservation sent a drone team (left) to Puerto Rico to inspect powerlines. Photo by NY DEC.



"DRONES: Is the Sky the Limit?," a large exhibition at the Intrepid Sea, Air and Space Museum that ran for much of the year, brought together a wide range of military and civilian drones. The Center for the Study of the Drone participated in the creation of the exhibit. Photo by Arthur Holland Michel.

private firms are developing their own in-house air traffic management systems for drones, including Alphabet, Gryphon Sensors, and Thales.

Others are focused on reducing the risk of crashes and injuries. Researchers at NASA are working on software that allows drones experiencing a malfunction to autonomously select the safest nearby landing zone. (Currently, drones are usually programmed to either land immediately or return to home, options which may not be feasible during a long-range operation). Researchers at École Polytechnique Fédérale de Lausanne are developing flexible multi-rotor drones that absorb the impact of a collision without breaking (rather than transferring the force of that impact to a person's head), as well as a delivery drone with a collapsible cage that protects its package during flight—a design that the team says allows one to keep fragile goods safe during transport without adding too much weight to the aircraft.

Drone Delivery

Amazon (see left of page) was not the only company active in drone delivery this year. Chinese retailer JD.com, which launched a drone delivery pilot program in 2016, was granted government approval to operate heavy-load delivery drones, and is looking to expand its drone delivery network to include 100 set routes. Switzerland granted drone delivery firm Matternet approval to fly autonomous drone delivery routes in the country, while Malawi launched an air corridor to test drones for medical deliveries and emergency response operations. Working with Matternet and e-commerce firm Siroop, Daimler Mercedes-Benz completed 100 package drop-offs in a drone delivery pilot program in Zurich. Alphabet launched a burrito drone delivery test program in rural Australia, and Turkish Post announced that it intends to join the growing list of postal companies hoping to someday delivery goods to customers autonomously through the air.

Looking Forward:

Next year, and in the years that follow, we will see major breakthroughs in the endurance of small civilian unmanned aircraft, which, coupled with likely advances in communications systems that allow drones to be operated over large distances, will have significant implications for commercial applications that are currently hindered by the short maximum flight time and range of most drones. Advances are also likely in commercial drone swarming technology and large, heavy-lift unmanned aircraft. Though further milestones in drone delivery are likely to be achieved in 2018, it is unlikely that we will see the implementation of a fully integrated routine drone delivery program this coming year.

AMAZON DRONES

Of all the entities that worked on civilian drone technology in 2017, Amazon stands out for the sheer number of headline-grabbing ideas that it produced. These include giant airborne fulfilment centers that can dispatch dozens of autonomous drones across wide areas, charging stations mounted atop lampposts and church spires, and retractable chutes that deliver packages from the airborne drone to the ground in a controlled manner. In a detailed report, we surveyed the more than 60 drone delivery system patents that Amazon has been awarded in recent years. Together, these patents offer detailed insights into how the company intends to make drone delivery a reality.

"The drone occupies imaginations in ways that infiltrate the future."

Kathryn Brimblecombe-Fox, whose painting "Drone Spiral" (above) was included in a portfolio published by the Center for the Study of the Drone in February.

DRONE ART

- Renowned street artist Banksy created a work called Civilian Drone Strike for an anti-war art exhibition outside the British Defense and Security Equipment International 2017 arms fair. The artwork, which depicts a childlike drawing of a strike, was auctioned for $260,000 and the proceeds were donated to two human rights groups.
- Hello, Robot, an exhibition at the Vitra Design Museum in Germany, explored the degree to which humans trust machines.
- The Imperial War Museum displayed a collection of works by Mahwish Chishty, who paints drones using millennial Pakistani fine art techniques.
- As Part of the Art Basel fair in Miami, Studio Drift and automaker BMW created a light show of 300 drones, while the Super Bowl halftime show featured a pre-recorded video of Lady Gaga performing under a swarm of drones flying in a formation of the U.S. flag.
- The Future of Life Institute released a short film about what it would look like if small, autonomous lethal drones fell into the wrong hands.

INDUSTRY

The past year was marked by a combination of increased growth in the civilian drone industry and a slew of challenges for drone manufacturers, including fines, employee layoffs, and concerns regarding user privacy and security.

In January, the Federal Aviation Administration fined Chicago-based drone operator SkyPan $200,000 for flying drones over urban areas. It is the largest fine that the FAA has issued to a drone operator. That same month, Lily Robotics shut down after announcing that it was unable to fulfill customer orders for the Lily flying camera. The Lily was unveiled in a viral 2015 promotional video and promised to usher in a new era for flying cameras. After receiving more than $34 million in pre-orders and $15 million in investment, the company folded when it failed to raise an additional $15 million in funding necessary to complete development and production. Days later, the company's offices were raided by the San Francisco District Attorney's office, which announced a civil consumer protection case against the firm. By June, Lily Robotics had auctioned off its assets and refunded about half of the 61,450 customers who had pre-ordered the drone.

A Donecle drone performs an autonomous inspection of a commercial aircraft at the Air France hangars in Toulouse, France. Image via Wikimedia.

Drone makers' money troubles, a trend that emerged in 2016, appeared to persist in 2017. In January, French drone maker Parrot announced that it would lay off around one third of its workforce after posting a $27.8 million loss in the third quarter of 2016. A few months later, the company said that it was moving to focus greater resources on prosumer and low-cost commercial systems. Yuneec and Autel Robotics, two other companies that began with a heavy consumer focus, also announced layoffs in 2017.

One of the greatest challenges these companies faced was stiff competition from China-based drone maker DJI, which still dominates the consumer drone market. That being said, DJI faced its own challenges in 2017. In May, responding to growing evidence that DJI drones were being used by extremist militant groups, the company introduced software updates that restricted flight operations in Iraq and Syria. In August, the U.S. Army banned the use of DJI drones due to concerns that they were transmitting sensitive data back to China. In November, a cyber-security researcher claimed that he had accidentally discovered a way to access DJI's confidential customer data. Meanwhile, a Department of Homeland Security Memo dated from August and published online in November raised concerns

PUBLIC SAFETY DRONES

Drone use by U.S. public safety departments continued to rise in 2017. In our April report "Drones at Home: Public Safety Drones," we found that there were more drone acquisitions by public safety departments in 2016 than in all prior years combined. So far, preliminary observations seem to suggest that public safety departments continued to acquire drones in large numbers both in the U.S. and abroad in 2017, a trend we expect to continue in the coming year. In France, for example, police began using drones to help identify dangerous drivers. During the Skirball fire in December, the Los Angeles Fire Department deployed drones for the first time to identify fire hotspots.

about whether DJI was sharing user data with the Chinese government (DJI denies these claims). The drone maker has moved to reassure users regarding the security of their data. In October, it introduced a privacy mode aimed at preventing user data from being transmitted over the Internet.

The past year saw several consolidations in the civilian drone industry. In January, DJI moved to acquire Hasselblad, the Swedish camera company. In February, telecommunications giant Verizon acquired Skyward, a provider of drone services and operations. In May, social media company Snap acquired Ctrl Me Robotics, a California-based firm that had aimed to provide drones to movie studios. France-based firm Drone Volt acquired a majority stake in Aerialtronics, a company that manufactures industrial drones, while drone services firm Measure acquired Pilatus Unmanned, a California-based company that designs drone payloads customized for specific industries.

Meanwhile, several notable partnerships and investments emerged in 2017. In March, John Deere partnered with Kespry to provide drones and data analytics software to customers in construction and forestry. DJI and 3DR, two companies that were once competitors for the consumer drone market, partnered to integrate 3DR's SiteScan software on DJI drones. Mercedes-Benz launched a partnership with Matternet to pair drones with delivery vans, while NVIDIA partnered with Komatsu, a Japanese construction giant, to use artificially-intelligent machinery and drones to improve the safety of construction sites. Last year also saw a number of major investments and successful funding rounds in the drone industry. Our research suggests that more than $500 million was invested into drone-related startups in 2017. *For a full list of these deals, see page 18.*

In spite of the challenges that drone companies faced in 2017, the industry continues to grow. According to a November report by the Center for the Study of the Drone, a total of 106,739 non-hobbyist drones were registered in the U.S. as of October 31, up from 39,066 at the end of 2016. The ranks of non-recreational users have increased threefold in 2017, rising from around 20,208 in January to 65,899 on December 1. That being said, not all of these users are reaping significant financial rewards; a survey by Skylogic Research found that the market for drone services is flooded by commercial drone pilots, most of whom conduct fewer than five operations per month.

Looking Forward:

Our April report on public safety drones and our November report on drone registrations both found that consumer drones like the DJI Phantom are overwhelmingly popular among non-recreational drone users. This, combined with moves by Parrot and other companies, suggests that the coming year will be marked by bids to disrupt the low-cost prosumer and commercial drone market. Meanwhile, regulatory uncertainty and the dearth in opportunities for certified remote pilots could pose a challenge for small businesses built around drone services. The FAA's UAS Integration Pilot Program could provide an opportunity for drone businesses to explore ways of establishing a more permanent presence in their communities. Finally, we expect that investments in drone startups will continue to shift to focus on software and enterprise services rather than new consumer drones, and that investments will increasingly pivot toward later-stage companies.

CIVILIAN DRONE COMPANY ACQUISITIONS

- Azur Drones acquired Sketech, a French manufacturer of industrial drones.
- Delta Drone acquired a majority stake in Techni Drone, a French drone services and education provider.
- Diversified Communications acquired Drone World Expo, uniting the Commercial UAV Expo and Drone World Expo industry events.
- Drone Volt acquired Aerialtronics, a Dutch firm that manufactures industrial drones.
- Ensign-Bickford Industries acquired Honeybee Robotics, a U.S. firm that manufactures robots for military and industrial applications.
- Measure acquired Pilatus, a U.S. firm that customizes drones for commercial applications.
- NV5 Global acquired Skyscene, a U.S. industrial drone services firm.
- Snap acquired Ctrl Me Robotics, a U.S. firm that specializes in small commercial drones.
- SoftBank acquired Boston Dynamics, a U.S. firm that manufacturs large robots.
- Verizon acquired Skyward, a U.S. drone services company.

APPENDIX

INVESTMENTS

Company	Country	Founded	Field	Amount ($M)	Month	Round	Leads	Source
3D Robotics	USA	2009	Industrial	53	May	D	Atlantic Bridge	Link
Abyss Solutions	Australia	2014	Industrial	1	May	Seed		Link
Aerobotics	South Africa	2014	Agriculture	0.6	August	Seed	4Di Capital, Savannah Fund	Link
Aeronyde	USA	2016	Software	4.7	December	Seed	JasTech Co	Link
Airdog	USA	2014	Hardware	0.303	August	Crowd		Link
AirMap	USA	2014	Software	26	February	B	Microsoft Ventures	Link
Airobotics	Israel	2014	Industrial	32	September	C	BlueRun Ventures China	Link
American Robotics	USA	2016	Agriculture	1.1	May	Seed	Angel Investors Network, BRC Innovation	Link
Arbe Robotics	Israel	2015	SAA	9	November	A	O.G. Tech Ventures, OurCrowd, Canaan Partners, iAngels, Taya Ventures	Link
Atlas Dynamics	USA	2015	Industrial	8	August			Link
Avision Robotics	USA	2014	Enterprise	0.15	May	Seed	500 Startups	Link
Betterview	USA	2014	Software	2	September	Venture	Compound	Link
Canard Drones	Spain	2015	Industrial	1.28	February			Link
Clear Flight Solutions	Netherlands	2012	Conservation	3.1	December	B	AERIUM Analytics, Cottonwood Euro Technology Fund	Link
Clobotics	China	2016	Hardware	5	June	A	GGV Vapital	Link
Dedrone	USA	2014	CUAS	15	February	B	Felicias Ventures, John Chambers	Link
Drone Racing League	USA	2015	Entertainment	20	June	B	Sky, Liberty Media Corporation, Lux Capital	Link
DroneSeed	USA	2015	Conservation	5.1	November	Venture		Link
DroneShield	Australia	2013	CUAS	2.32	October			Link
EagleEye Intelligence	USA	2015	Hardware	6	August	B	Stonehenge Growth Equity Partners	Link
Elroy Air	USA	2016	Delivery	4.6	December	Seed	Levitate Capital, Homebrew, Shasta Ventures, Lemnos	Link

INVESTMENTS

Company	Country	Founded	Field	Amount ($M)	Month	Round	Leads	Source
EWatt Technology	China	2010	Industrial	20	September	B	Chaoyong Wang	Link
Flirtey	USA	2013	Delivery	16	January	A	Menlo Ventures	Link
Flytrex	Israel	2013	Delivery	3	January	A	Amanda Capital AG	Link
Fortem Technologies	USA	2016	CUAS	5.5	May	Seed	Signia Venture Partners, Data Collective	Link
Gamaya	Switzerland	2015	Agriculture	4.3	September			Link
Iris Automation	USA	2015	SAA	1.5	January	Seed	Bee Partners	Link
Kespry	USA	2013	Industrial	33	December	C	G2VP	Link
Kittyhawk	USA	2015	Software	1	March	Seed	The Flying Object	Link
MakeBlock	China	2011	Education	30		B	Shenzhen Capital Group	Link
Measure	USA	2014	Industrial	15	January	B	Cognizant Technology Solutions	Link
MicroMultiCopter Aero Technology	China		Hardware	30	November	Venture	Plum Ventures	Link
Neurala	USA	2006	Autonomy/ AI	14	January	A	Pelion Ventures	Link
Nongtian Guanjia	China	2016	Agriculture	7	June	A	Gobi Partners	Link
Saildrone	USA	2012	Maritime	12	February	A		Link
Sky-Futures	UK	2016		4	August	B	Mitsui & Co	Link
Skydio	USA	2014	Autonomy/ AI	28	August	B		Link
SkySafe	USA	2015	CUAS	11.5	July	A	Andreessen Horowitz	Link
SkyX	Canada	2015	Hardware	4	May	Venture	Kuang-Chi Group	Link
Starship Technologies	USA	2014	Delivery	17.2	January	Seed	Daimler	Link
Swift Navigation	USA	2012	Autonomy/ AI	34	June	B	New Enterprise Associates	Link
uAvionix	USA	2014	Hardware	5	November	B	Airbus Ventures	Link
vHive	Israel	2016	Software	2	April	Seed	StageOne	Link
WhiteFox Defense Technologies	USA	2015	CUAS	2	June	Seed	Serra Ventures	Link
WiBotic	USA	2015	Hardware	2.5	April	Seed	Tsing Capital	Link

MILITARY UNMANNED AIRCRAFT UNVEILED IN 2017

Country	Company	Platform	Class	Type	Endurance (hrs)	Range (km)	Ceiling (m)	Speed (km/h)	MTOW (kg)	Payload (kg)	Wingspan/ Rotor (m)	Length (m)	Source
Belarus	Indela	Belar Ys-Ex	Heavy	Fixed	24			300	1400	280	11.5	8.9	Link
Brazil	FT Sistemas	FT-200 FH	Medium	Rotary	12	100	3657		80	50	2.8		Link
China	AVIC	A-Hawk I	Light	Rotary	0.5		3000	60	175		3.47		Link
China	AVIC	A-Hawk II	Light	Rotary	4		5000	60	120				Link
China	AVIC	AV500W	Medium	Rotary	8	200		170	470	160		7.2	Link
China	Beihang	TYW-1	Heavy	Fixed	40		7500	200	1500	370	18	9.85	Link
China	Chinese Academy of Sciences	AT200	Heavy	Fixed	8	2183	6100	313	3175	1500	12.8	11.8	Link
China	Tengden	HA001	Medium	Rotary	6				450				Link
China	Tengden	HB001	Medium	Rotary	5				280				Link
China	Tengden	TA001	Heavy	Fixed	24				1200				Link
China	Tengden	TB001	Heavy	Fixed	35	6000	8000		2800		20	10	Link
China	Ziyan	Blowfish	Light	Rotary	0.8			150	24.7	15	1.87		Link
Czech Rep.	NST	CANTAS E	Medium	Fixed	18		3000	160	65	10	2.4	5	Link
India	CSIR-NAL	Suchan	Light	Fixed	1	10	300	108	3.5		1.6	1.3	Link
Israel	Aeronautics	Pegasus 120	Light	Rotary		10		83	120	75			Link
Israel	APG	Peres	Medium	Hybrid	12				220	20	4	4	Link
Israel	Elbit	Hermes 45	Light	Fixed	24	250	4572		65	15			Link
Israel	Flying Production	Thor	Light	Rotary	1.25	10	609		12.5	3			Link
Israel	UVision	Hero -400EC	Light	Fixed	2				40	10	2.4	2.1	Link
KSA	KACST	Saqr-1	Heavy	Fixed	24	2500	6707		1400	250	18	9.2	Link
Russia	Kronshtadt	Orion	Heavy	Fixed	24	300	7500		1000	60-200	16	8	Link
Russia	VR Technologies	VRT300	Medium	Rotary		150		180	300	70			Link
Russia	Zala Aero	ZALA 421-16E2	Light	Fixed	4	30	3600	110	7.5	1.5	2.8		Link
Serbia	EDePro	X-01Hornet	Medium	Rotary	4		3962	180	750	350	7.6	6.75	Link
Singapore	DSO	V15	Light	Hybrid	3				15		3.5	1.8	Link
Switzerland	Aeroscout	Scout B-330	Medium	Rotary	3		3050		140	50	1.04	4.2	Link

MILITARY UNMANNED AIRCRAFT UNVEILED IN 2017

Country	Company	Platform	Class	Type	Endurance (hrs)	Range (km)	Ceiling (m)	Speed (km/h)	MTOW (kg)	Payload (kg)	Wingspan/ Rotor (m)	Length (m)	Source
Switzerland	UMS SKELDAR	R-350	Medium	Rotary	2	80	2500	120	150	30	3.5	3.2	Link
Ukraine	Antonov	Horlytsya	Medium	Fixed	7	1050	2400	180	200	50	6.7		Link
USA	AeroVironment	Snipe Nano	Light	Rotary	0.25	1			0.14				Link
USA	Lockheed Martin	Outrider	Light	Fixed	2	40		93	1.7				Link
USA	Textron	Nightwarden	Medium	Fixed	15	1100	6096	167	340	59	7		Link

MILITARY UNMANNED GROUND AND SEA VEHICLES UNVEILED IN 2017

Country	Company	Platform	Type	Endurance (hrs)	Range (km)	Speed (km/h)	Weight (kg)	Payload (kg)	Length (m)	Width (m)	Source
Australia	Praesidium Global	Pathfinder	Ground	48							Link
Belarus	BSVT	Bogomol	Ground	<24	100	5	800				Link
China	Harbin Engineering University and HiSiBi	Tianxing-1	Sea			92.6	7500		12.2		Link
China	Yunzhou-Tech	M80B	Sea	6	185	15	1400	150	5.65		Link
Germany	Rheinmetall	MM UGV	Ground	8-24		40	750	600			Link
India	DRDO	Muntra	Ground	*Specifications not available.*							Link
Indonesia	BDLtechnology	WAR-V2	Ground	*Specifications not available.*							Link
Israel	Meteor Aerospace	RAMBOW	Ground		160			700			Link
Israel	Roboteam	TIGR	Ground	15	1.3	10.5	74		0.91	0.59	Link
Russia	Rubin Design Bureau	Amulet	Sea		15		25		1.6		Link
Singapore	ST Kinetics	Jaeger 6	Ground						2.4		Link
ROK	DAPA	Haegeom	Sea			54	3000		8		Link
UK	BAE Systems	Ironclad	Ground		50		200	250			Link
UK	Digital Concepts Engineering	X-2	Ground	4-8	1	5	300	250	1.31	0.86	Link
Ukraine	Robotics Design Bureau	RSVK-M2	Ground		20	10-30			2	1.25	Link
Ukraine	SpetsTechnoExport	Phantom	Ground		10			350	3	1.6	Link
USA	Remotec	Nomad	Ground				74		0.9	0.6	Link
USA	HDT Global	Hunter WOLF	Ground	72	100	32	1100	450	2.3	1.4	Link
USA	Argo	J8XTR	Ground			30	750	570	1.16	0.6	Link

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