

Unmanned Aerial Vehicles (UAV): Drones for Military and Civilian Use

Droning On: The Rise of Remote Piloted Flying

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Then there are the non-organic "microdrone" robotic flying craft, not much larger than the living counterparts that inspired these drones — including one known as the RoboBee. While scientists and engineers are trying to get microdrones to work together like a swarm of bees, the military is considering their use in spying and general surveillance, to supplement the much bigger drones that most people are familiar with.

How Can Drones Be Used?

Drones of all types have already been used in a wide range of practical ways , including:

- Archaeological surveying.
- Science, in general.
- Environmental/meteorology; e.g., climate study, storm monitoring, mapping glaciers, general data collection.
- Military — surveillance, air strikes.
- Security — surveillance, crowd monitoring and control.
- Law enforcement — surveillance, traffic monitoring, search and rescue operations

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- Security — surveillance, crowd monitoring and control.
- Law enforcement — surveillance, traffic monitoring, search and rescue operations, aiding hostage situations and for bomb threats, tracking a fleeing criminal.
- Firefighting — forest and fire monitoring, risk management. A volunteer fire firefighter in Connecticut used his personal \$1200 DJI Phantom quadcopter as a drone to help monitor a fire situation at an industrial location by streaming video back, which helped determine how far the fire was from a storage unit containing explosives.
- Healthcare, including medical supplies delivery. E.g., vaccines, defibrillators to people in emergencies, or other supplies, especially in remote areas.
- Farming — crop and livestock monitoring.
- Meat plant inspections, including catching companies dumping animal blood into nearby bodies of water.
- Commercial use — delivery. Amazon's Jeff Bezo's talked about future delivery by drone. Domino's Pizza pulled a PR stunt delivering pizza. Lakemaid Beer, a Minnesota brewery, delivered cases of beer to ice fishermen before they were told to stop by the FAA (Federal Aviation Administration). In the U.S., the FAA (Federal Aviation Administration) has a say in how drones are used for commercial tasks.
- Aerial photography, including architectural photography, photographing music festivals.
- Shooting movies, TV shows, TV commercials.
- Thermography — inspection of solar systems, wind turbines, power lines using thermal imaging cameras.
- Land inspection and surveying.
- As scarecrows, to scare large flocks of geese near public parks in Ottawa, Canada.
- Pipeline and oil rig inspection using infrared cameras.
- Crop management, including spraying and watering.
- Monitoring marine life, including whale watching.
- Wildlife conservation, including tracking orangutans in Sumatra and monitoring several

endangered species. Namibia has teamed up with the WWF (World Wildlife Fund) to fly drones over national national parks, in hopes of spotting poachers, as well as monitoring animals.

Types of Drones

There are several types of drones that can be used collectively for the purposes above. Here are a few, which come in all shapes and sizes.

- Quadcopters, as well those with 6 or even 8 blades.
- Larger unmanned aerial vehicles (UAV) that resemble small helicopters and planes, and sometimes even larger planes.
- Microdrones, which are insects-sized and sometimes insect-shaped, and having flapping wings. There are also somewhat larger bird-inspired drones with flapping wings.

Bird and Insect Drones

- 80% of world's animal species (900K types) are Insects and their relatives
- Microdrones are the result of insect-inspired flying vehicles
- This required high-speed photography to understand the aerodynamics of insects.
- Torkel Weis-Fogh, a Danish zoologist, studied wing motion of hovering insects in the 1970s, using high-speed photography. He came up with the "clap-and-fling effect" theory of insect flight, which is based on how insect wings create a spiral of air that pushes the insect up or forwards on each beat of their wings.
- In the 1990s, one of his former students, Charles Ellington, also a zoologist, created a robotic wing that mimicked hawk moth movements.
- Neurobiologist Michael Dickinson built a robotic wing inspired by the fruit fly. In 1998, he electrical engineer Ron Fearing won a \$2.5M DARPA grant to create a fly-sized model — successfully accomplished after 7 years by Rob Wood, who had started the project while still a grad student.
- TechJet created a robotic dragonfly with a 6-in wingspan, weight 5.5 grams (less than an American quarter).
- The Delfly Explorer is the world's smallest non-tethered drone with flapping wings, at 20 gm in weight, with a 28cm wingspan. (The RoboBee is tethered.)
- The British military is already using non-insect-shaped microdrones for scouting missions in Afghanistan.
- Other insect- and bird-inspired drones include the Nano Hummingbird, Dragonfly and RoboBee.
- The RoboBees creator, Rob Wood, speculates that they could be used in swarms at disaster sites to search for survivors.

Drone Swarms

Robotic insect swarms are actually difficult to produce because of limitations on battery life, especially at microdrone sizes. However, Hungarian researchers have managed to assemble a team of 10 drones that self-organize themselves as they fly.

- These quadcopters have GPS, wireless radios and processors which collectively allow the pack to navigate in a formation, follow a leader, and more.
- The team behavior was modeled after pigeons.

Other researchers have videos on YouTube showing packs of multiple mini quadcopters working in a team to do something athletic or musical.

Killer Drones

While most uses of drones are non-destructive, some are used for unmanned military strikes against enemies. Usually referred to as UAVs (Unmanned Aerial Vehicles), they come in a variety of shapes and sizes, some of which carrying missiles.

- While drones are remotely controlled, some can take off and land on their own, even from aircraft carriers.
- U.S. DOD (Dept of Defense) spending on drones increased from \$284M in 2000 to \$3.3B in the fiscal year previous (to Oct 2012).
- 31% of all U.S. Military aircraft are drones (as of September 2012). This includes tiny spies, not just large, glider-sized drones. For example, the Army's 5,346 Ravens.
- In 2005, only 5% of military aircraft were robots.
- In 7 years time, the military has 7,494 drones, compared to 10,767 manned aircraft.
- The Military has 161 Reapers and Predators, the latter used as flying strike drones in Pakistan, Yemen and other places.
- While manned aircraft still get 92% of Pentagon aircraft budget money, the U.S. Military has spent \$26B on drones since 2001.
- Drones are getting safer to operate. 38 Predators and Reapers crashed in Iraq and Afghanistan as of September 2012 or earlier. However, Predators get 7.5 accidents per 100K hours of flight — a decrease from 20 accidents per 100K hours in 2005.
- A Global Hawk eats up data communication bandwidths of 500MB (Megabytes) per second — which is 5 times the total bandwidth used by the whole U.S. Military during 1991 Gulf War.
- The Air Force is hoping for a super/ hyper-sonic drone by 2034.
- Some facts about the Predator drone:
 - Flies similar to other small aircraft.
 - Unmanned but remotely piloted.
 - Has a 4-cylinder, 4-stroke, 101 hp engine.
 - The remote pilot can control the propellers
 - Has a top speed of 135 mph, and top altitude of 25,000 ft.
 - The U.S. Dept of Defense says that the Predator is more than an aircraft, it's a system. It takes around 82 people in total to manage four drones successfully for 24-hour surveillance in a 400-nautical mile radius.
 - Involved in a system are four Predator drones, ground control and a satellite link.
 - Each Predator has a pilot and two sensor operators.
- The U.S. and the UK are the only countries operating drones in Afghanistan. They collectively launched nearly 1200 drone strikes over the 5 years spanning 2008-2012, inclusive. (Libya figures are until September 2, 2011; Yemen figures are confirmed strikes only.)
 - Libya (2011): 105
 - Iraq: (2008-2012): 43, 4, 0, 1, 0 = 48 total
 - Yemen: (2011-12): 13, 28 = 41 total
 - Pakistan: (2008-2012): 38, 55, 128, 75, 44 = 340 total
 - Afghanistan: (2008-2012): 130, 196, 206, 238, 245 = 1015 total
- These are just the drone strikes. Drone "sorties" are greater in number. In Afghanistan, there were a total of 36,481 sorties in the same time period, with 1,358 missiles fired by drones during the 1,015 strikes.
- By comparison, the CIA has only carried out 338 attacks in Pakistan during the same period.
- An UN agency, UNAMA (United nations Assistance Mission in Afghanistan) found that the

number of civilian drone-inflicted deaths in Afghanistan tripled in 2013.

- The UK drones, despite being lesser in number, conducted over a fifth of the strikes.
- 19 separate incidents of civilian deaths were identified by UNAMA.
- In addition to these deaths, there are those caused in other related, non-drone violence — nearly 3,000 non-combatants died in 2013, including 1300 women and children.
- 75% of these fatalities were caused by Taliban and other insurgents.
- Nearly 1,000 civilians were killed by insurgents with improvised explosive devices.
- 2% of civilian deaths in 2013 were from international air operations, down from 10% in 2012.
- Some stats on CIA drone strikes in Pakistan, 2004-2013:
 - Since 2004: 381 (330 under Obama administration, the rest under Bush)
 - Reported killed: 2,537-3,646
 - Civilians: 416-951
 - Children: 168-200
 - Reported injured: 1,128-1,557
- The graph of CIA drone strikes in Pakistan by year, for 2004-2013, shows a “bell curve” for both number of strikes and casualties — which suggests that maybe the U.S. and UK war effort there may be declining, but at least that casualties are declining. The similarity of shapes strongly suggests that civilian casualties in 2010 climbed to a peak of 874 (total number killed) because that was also a peak year for strikes in Pakistan.

It should be noted that the U.S. military definition of “combatant” is a bit loose, making it possible to claim that no civilians were killed in a particular drone strike. According to the Bureau of Investigative Journalism, if an intended target is killed in a strike and nearby males of military age are also killed, they are deemed “combatants” — even if, according to investigative journalists and UN investigators, they were simply innocent male civilians. Also, critics of the killer drones — including one writer in The Guardian who claims to have worked on the U.S. drone program — point out that video feedback is so poor that you cannot tell the difference between a shovel and a gun. A remote pilot under pressure may end up striking unintended targets. Fortunately, future military drones will be smaller and have more accurate weapons, presumably resulting in lower numbers of civilian casualties. It’s very likely that we’ll see ever more drones in the near future, including in the USA, for law enforcement and general surveillance. While some uses are destructive, most are valuable to many fields and industries.



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