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DRONES: BUILD TYPES

By Susan Giannantonio, P.E., and Jeff MacKay, P.E., NTM Engineering, Inc.

Drones, more formally called unmanned aerial vehicles (UAV), are aircraft that operate without the possibility of direct human intervention from within or on the aircraft (FAA.gov). The total system, including the aircraft, its operating software, and remote controls for operating the aircraft are collectively referred to as unmanned aircraft systems (UAS). Drones are used for a wide variety of applications in industries such as transportation, agriculture, military, and recreation. Uses include photography and videography, visual inspections, thermal imaging, three-dimensional scans, aerial mapping, vegetation/agricultural monitoring and applications, construction monitoring, and forestry/environmental/utility surveys. Public works and transportation departments across the United States are evaluating the potential benefits of drones and their ability to supplement or enhance human workers performing day-to-day and safety-critical tasks.

Public works departments may consider the use of a drone to collect photographic documentation of infrastructure that is difficult to access safely. For example, drones may collect video and photographs of bridges, buildings, and active construction sites. Inspectors can analyze the images to determine the specific areas that require in-person inspections, vastly improving safety by minimizing the time workers spend in hazardous situations. This technology provides a useful tool to augment municipal workers' "toolbox" of skills to serve the community.

There are several classes of drones; each being better suited for different purposes. Potential users should assess their intended uses to determine the most suitable drone for their program needs. For example, some types of drones offer the ability to hover in place which is a key advantage for completing infrastructure inspections. Drones are categorized into four types of builds:

- Multi-Rotor,
- Fixed Wing,
- Single Rotor, and
- Fixed Wing Hybrid Vertical Take-Off and Landing.

Multi-Rotor Drones

The most widely used class of drones is multi-rotor. These drones use three or more rotors with fixed-pitch spinning blades that generate lift. Multi-rotor drones are typically found with three, four, six, or eight rotors; these configurations are known respectively as tricopters, quadcopters, hexacopters, and octocopters. Quadcopters are the most common design, having a less complex stabilizing mechanism than tricopters and fewer parts than hexacopters or octocopters.

A lower-end single camera quadcopter with professional capabilities is around $3,000. Higher-end models can exceed $30,000 with interchangeable cameras, infrared, and other data collection attachments.

A quadcopter multi-rotor drone provides good hovering capabilities. Photo: NTM Engineering

Advantages:
Low cost
Vertical lift-off/landing
Agile
Easiest to pilot

Disadvantages:
Limited flight time
Limited weight carrying capacity
Back-up battery cost can be cost prohibitive

pennsylvania
DEPARTMENT OF TRANSPORTATION
LOCAL TECHNICAL ASSISTANCE PROGRAM

400 North Street, 6th Floor
Harrisburg, PA 17120
1-800-FOR-LTAP • FAX (717) 783-9152
gis.penndot.gov/ltap

Fixed-Wing Drones

A fixed-wing drone looks similar to a traditional commercial travel plane but in a miniature scale. Its flight comes from traditional air lift on the wings generated by forward motion provided by a propeller turned by an electric motor. This type of drone requires a runway or a launcher for takeoff and an adequate landing area. While it can travel longer distances, it cannot hover in place for inspection and similar uses.

A fixed-wing drone can carry heavy payloads but is more difficult to operate. Photo: Gerald Nino, US Customs & boarder Protection, Public Use, wikimedia, accessed 2023-09-20

Advantages:
Longer flight times than multi-rotor
Higher flight capabilities than multi-rotor
Higher weight carry capabilities than multi-rotor
More stable in difficult weather conditions

Disadvantages:
Difficult to pilot
Large compared to other types
Unable to hover
Limited launch/landing locations

Single-Rotor Drones

Much like a traditional helicopter, single-rotor drones use a single rotary blade to provide lift and a tail rotor to control direction and stability. The single-rotor layout is more energy efficient than the multi-rotor designs but tend to experience more vibration during operation. The higher energy efficiency allows for higher payloads. This type of drone often uses gas engines instead of battery-powered engines, resulting in dramatically increased range. They can be unpredictable and unstable on landing.

Advantages:
Heavy payload capability
Faster speed than multi-rotor
Longer flight times (gas powered)

Disadvantages:
Unstable, difficult landings
Harder to pilot/advanced training needed
Larger blades are more dangerous
Higher costs

Fixed-Wing Hybrid VTOL Drones

Fixed-wing hybrid vertical take-off and landing (VTOL) drones combine both rotor and fixed-wing technology for increased versatility. They utilize rotors to allow vertical lift off and landing, eliminating the need for launchers or runways. Incorporating fixed wings to support operation during flight increases the longevity, distance and speed capabilities compared to drones using just one flight method.

Advantages:
Extended forward flight time and hovering capabilities
Vertical lift-off and landing

Disadvantages:
Extremely costly equipment
Less stable/harder to control than other types
Not as effective as the individual counterpart for either capability (rotary or fixed)

A fixed-wing hybrid VTOL drone can fly long distances. Photo: PennDOT

Understanding the capabilities offered by each type of drone in comparison to the desired use will help determine the best choice for a specific program. Regardless of the drone type chosen, the pilot's experience is critical. All drones require skill and practice to achieve safe operations and effective use. Pilots must adhere to applicable Federal Aviation Administration regulations including pilot certification, drone registration and flight requirements.