Which drones are the best for mapping?

Written by
ERIC ANDELIN
Senior Workflow Specialist at SimActive Inc.

The answer depends on what you are trying to map (or model) and how large that area is. First, there is a distinction between mapping and modeling.

A map is a top-down representation of features on the ground laid out spatially in a way that you could measure the distance between any two points on that map (e.g. Google Earth is a map of the earth). Maps can also have an elevation component to them as well either displayed via contouring or as a Z value embedded in each pixel of a raster DEM. A model is a 3D recreation of an object or structure (e.g. Google Earth, in some places, has 3D modeled cities that can be viewed as a layer over the map). While both are derived from imagery, different drones are more suited for each.

AIRFRAMES

Multirotors

DJI, Microdrones and Skydio are probably the most well known manufacturers in this space. Of the three, DJI and Microdrones are also capable of acquiring imagery for mapping. Skydio's focus is in autonomous modeling. With no aerodynamic properties, multirotors rely on constant power to stay aloft, much like a helicopter. They can also hover in place like a helicopter. This maneuverability comes at a price though, and that is flight duration. Typically they fly 15 to 30 minutes, therefore the area that they can map per flight is relatively small.

Multirotor drones, especially the smaller ones with clash detection and obstacle avoidance such as Skydio and DJI excel at modeling. They have the ability to hover around an object and sometimes even inside or below the object. Multirotor drones are equipped with gimbals to support and control their payloads allowing them to capture imagery at any angle. All these are required for high quality modeling.

Fixed Wing

Fixed wing drones have all the aerodynamic properties of conventional aircraft relying primarily on lift and power to keep them in the air. They are always in forward motion, therefore not well suited for modeling. However, fixed wing drones are very efficient and can typically operate for much longer durations per flight. This allows for mapping of much larger areas. Systems from Wingtra, Quantum-Systems and SenseFly can all fly 2 to 4 times longer than the majority of multirotor drones.

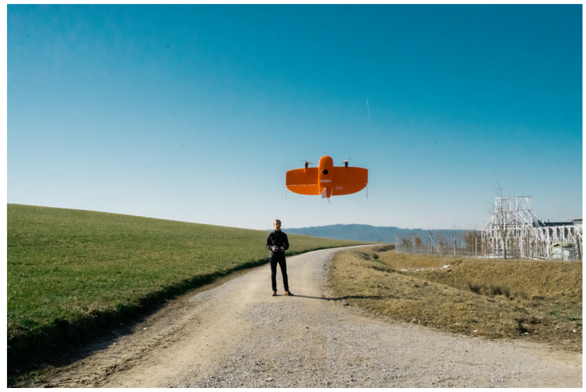
VTOL Fixed Wings

Of the three fixed wings listed above, the Wingtra and Quantum-Systems also have vertical takeoff and landing (VTOL) capabilities allowing them to launch and land without the need for a runway or open field.

SENSOR TECHNOLOGY

Multirotor drones currently carry a wide variety of sensors. This is due to their increased lift capabilities, the ability to stop and hover during flight, and the incorporation of gimbals to control some sensors. Most have RGB cameras with zoom and video capture capabilities. Others have thermal sensors or multispectral cameras, or a combination of all three. Finally, larger multirotors can carry LiDAR sensors for high accuracy mapping.

Fixed wing drones carry fewer payloads primarily because of their constant forward flight characteristics and weight limits. Sensors can range from RGB cameras such as Sony brands and the metric Phase One line of cameras, Flir thermal, and MicaSense multispectral. Sensors with fixed focal length lenses (better suited for mapping) can typically be found underneath fixed wing drones. LiDAR sensors are now available for some fixed wing systems.



Metric vs commercial off-the-shelf (COTS) camera technology

Metric cameras have precise known measurements and are not susceptible to deviations due to environmental conditions. They typically have the highest quality fixed focal length lenses, and are professionally calibrated by the manufacturer to ensure all parameters are known. These are found more often in mid size or large format cameras.

The majority of the sensors supplied with commercial drones do not have fixed focal length lenses and their internal parameters are not known. This can result in less than optimal mapping results. This is why photogrammetry software such as SimActive's Correlator3D allows for sensor calibration during the aerial triangulation process to calculate the camera's true parameters.

Positioning systems

Both multirotor and fixed wing drones carry onboard GPS to determine and report their location at any given moment. When using a drone for modeling or mapping, each image captured gets tagged (i.e. geotagged) with location and altitude at the time of capture. This allows mapping software such as SimActive's Correlator3D to import and assemble images for aerotriangulation and bundle adjustment.

Basic GPS

Basic GPS information is accurate to approximately 3 meters. During post-processing, the processing software will refine this error and eliminate it relative to the scene being mapped during aerotriangulation using a fully unconstrained bundle adjustment process. When coupled with ground control, the resulting DEM and orthomosaic can be extremely accurate. However, there are other more robust GPS solutions used onboard some drones. These solutions are real-time kinematic (RTK) and post-processed kinematic (PPK) GPS.

Real-time kinematic (RTK) GPS

RTK requires a base station preferably on site, collecting GPS information in tandem with the drone. The drone's position is then refined and corrected in real time. This can bring the drones' reported position from meters into the centimeter range.

The potential drawback is that if the base and the drone lose their connection, there is no recovery. Therefore it is recommended that the drone's onboard GPS be capable of acquiring both the L1 and L2 GPS signals for redundancy.

Post-processed kinematic (PPK) GPS

PPK does the same as RTK, without an onsite base station. Instead, it relies on a network of established stations (or private networks), selecting the nearest operating one and applying a correction to the drones reported position via post-processing.

The drawbacks can be the delay in receiving a post-processed solution. This can take as little as an hour for initial results to days if the most accurate results from the ephemeris solution are desired. Proximity to the nearest operating station can affect results, and in some areas there may not be an operating station eliminating the ability to use PPK, or requiring someone to use their own base.

PPK was originally designed to be used in mapping projects where the placement of ground control would be extremely difficult. However, in either case (RTK or PPK), control is still required to generate the most accurate mapping results.

Inertial measurement unit (IMU)

The final positioning component is the inertial measurement unit (IMU). Where GPS provides the Z,Y, and Z location of the drone, the IMU provides the exact orientation roll, pitch, and yaw aka omega, phi, and kappa. These are necessary when using a fully constrained aerotriangulation or direct georeferencing solution for your bundle adjustment in a photogrammetry software such as Correlator3D. Like onboard GPS equipment, the quality of the IMU can greatly affect results of processing. In fact, the typical IMU that comes installed on COTS drones should not be used with constrained AT or direct georeferencing bundle adjustments. These are for extremely precise IMUs such as the Applanix and Novatel systems.

Summary

Each type of drone has its own benefits and excels for specific uses. The following is a table breaking them down.

DRONE	Type	Launch Style	Flight Duration	Suitable for Modeling	Suitable for Mapping	RTK Option	PPK Option
DJI M300	Multi Rotor	VTOL	30 Min	✶✶✶	✶✶✶	✓	✓
Microdrones mdMapper 1000	Multi Rotor	VTOL	45 Min	✶✶	✶✶✶✶	✓	✓
Skydio X2	Multi Rotor	VTOL	20 Min	✶✶✶✶✶	✶✶	⊘	⊘
Wingtra One	Fixed Wing	VTOL	60 Min	⊘	✶✶✶✶✶	⊘	✓
Quantum Systems Trinity F90+	Fixed Wing	VTOL	60 Min	⊘	✶✶✶✶✶	⊘	✓
Sensefly eBee X	Fixed Wing	Hand	60 Min	⊘	✶✶✶✶	✓	✓

Note there are base models and upgraded models represented here. Costs can vary widely given the options chosen. Also, this is a list of the more popular drones on the market today. There are many others available that may suit a specific need better than these. When choosing a drone or drones for your program, consider the type of work you will most likely be doing.

Consider your accuracy requirements, and the additional expense of survey equipment necessary for RTK solutions. Or conversely, possible cost savings over time with a PPK solution. Lastly typical project size: will hot swapping batteries with multirotors suffice or should you go for a fixed wing with longer flight durations?