WHITE PAPER

DIFFERENT TYPES OF UAVs

When browsing around the drone market and trying to decide which aircraft is best suitable to one's business needs, it is easy to get confused with the many configurations and solutions available. With an expected rise in drone development and operations in the upcoming years, it is important **to navigate wisely throughout this drone market jungle in order to make a well thought-through and informed decision on a drone purchase.**

This white paper offers a break-down of the different UAV types that are currently available in the market, explains their main differences, points out their respective strengths and weaknesses.

THE EVOLUTION OF UNMANNED AIRCRAFT TECHNOLOGY

> *Like many technological innovations, unmanned aircrafts originated and were initially built for the defense sector. There were several short-lived, commercially unrealized attempts at conceptualizing an unmanned aircraft as early as the beginning of the 20th century.*

De Havilland DH.82B QueenBee, built in 1935 is considered by many experts to be the first real ancestor of the modern drone. The Queen Bee was devised as a low-cost radio-controlled target aircraft. It used an internal combustion engine, unslotted wings, under-carriage and a wooden fuselage. In order to cope with the high forward accelerations experienced in a catapult launch, its carburetor was reversed.

Although some electrical prototypes were built during the 20th century, at the time this technology was underdeveloped and expensive, so proper electric UAVs did not have their breakthrough until early 2000's. Notably, internal combustion engine-based UAVs have longer endurance due to their high power and energy densities, nevertheless they need an auxiliary starting motor, their control is more complex, and their acoustic and thermal signatures are relatively high.

In recent years, **electric UAVs are favored for some of their key features such as reduced noise and thermal signatures, high efficiency, zero carbon emission,** self-starting and developed control devices enabling high maneuverability. Therefore, in the context of this white paper, the focus is going to be on all electrical UAV's.

CLASSIFICATION OF MODERN DRONES

A wide variety of UAV solutions have been developed and can be classified by parameters as the methods of lift-off, specifics of aerodynamic design, range of flight, methods of control, radius of action, take-off weight and other parameters. Furthermore, there can be several sub-divisions in each class.

Notably, most important initial drone market segmentation is classification by drone market category.

> *In the drone market, there are three main categories: (1) Consumer drones for recreational use, (2) Commercial drones for industrial applications and (3) drones for Defense/Military sector.*

In several latest surveys it is noted that in the upcoming years, **the most significant increase is going to be in the commercial drone market category,** therefore in the context of this white paper the focus is going to be on industrial applications of drones.

Association for Uncrewed Vehicle Systems International (AUVSI) has developed UAV classification depending on take-off weight and operational range:

UAV Class	Take-off Weight (kg)	Range (km)
Short-range nano UAV	max 0.25	max 2
Short-range micro- & mini-UAV	max 5	25-40
Light short-range UAV	5-50	10-70
Light medium-range UAV	50-100	70-150 (250)
Medium UAV	100-300	150-1000
Medium heavy UAV	300-500	70-300
Heavy medium-range UAV	500-1500	70-300
Heavy long-range UAV	1500+	1500

However, despite many other classifications briefly described above, the most commonly used classification for different types of UAV's in the commercial drone market is following:

(1) Fixed wing (airplane type)
(2) Rotary wing (single rotor or multirotor type)
(3) Hybrid (Fixed wing VTOL)

Now let's dig deeper into these types of aircrafts, identify their respective strengths and limitations.

FIXED WING TECHNOLOGY

As the title suggests, fixed-wing drone is like an airplane – it only needs rotors to move forward, while the aerodynamic wing ensures sufficient lift. Because of this, the fixed wing drone only need to use energy to propel itself forward, not sustain itself up in the air and therefore are much more efficient.

For the reasons mentioned above, fixed wing drones are great for large scale missions that require long endurance/range. This type of drones would be great for missions that require lengthy loitering around the point of interest while monitoring it. Because of the specifics of the aerodynamic design, fixed-wings can gather data with greater speed, as their average cruising speeds vary from 60-72 km/h.

There are, however, several drawbacks to be aware of when considering the purchase of a fixed-wing drone:

1. They have no ability to hover in one spot, which limits their field of applications;
2. Launching and landing a fixed-wing drone is trickier and more complex, as depending on their size, they typically need a runway or catapult launcher to get them airborne, and either a runway, parachute or net to recover them safely;
3. High costs that consist not only from the aircraft itself, but all the additional mechanisms that are needed to operate it, as well as the extensive training required;
4. As these types of drones are associated with specific use, cannot be used by a regular drone operator, but rather require advanced piloting skills;
5. When parachute landing a fixed wing drone, it is unpredictable where the drone lands. Gusts of wind can throw it off the expected landing area;
6. Relatively high-risk purchase – if technology malfunctions or upon human error, is a costly loss.

ROTARY WING TECHNOLOGY

Also known as copters or multi-rotors, these are the easiest to obtain and the cheapest drones that can cover basic tasks for a relatively short amount of time. The advantage of copter drones is they give great control over position and framing, making them suitable for such tasks as indoor inspections or vertical structure inspections that require precise upside-down hovering motion.

Main challenges for copter drones in industrial applications are:

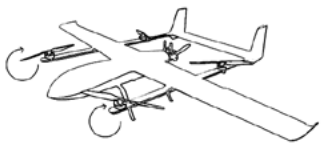
1. Unsuitability for large scale aerial mapping, long endurance monitoring and long-distance inspection such as pipelines, roads and power lines due to limited endurance
2. Require a lot of battery energy just to fight gravity and keep them afloat
3. Limited payload due to absence of wing lift force during flight
4. Sensitivity to geomagnetic abnormalities, which occur for example in mountainous areas
5. Mostly manual control, which means increased risk of human error
6. VLOS/ EVLOS flights only
7. Returns back home if the telemetry signal is lost

VTOL (VERTICAL TAKE-OFF AND LANDING) TECHNOLOGY

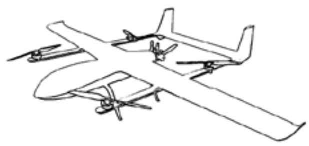
As the term Hybrid VTOL suggests, **the aircraft are equipped with multiple rotors that ensure vertical take-off and landing, and they transition to an airplane mode during the flight.**

Several manufacturers have tried to overcome the limitations fixed wing and copter drones have, but still, many of the solutions currently available on the market face significant challenges limiting the functionality of these aircrafts.

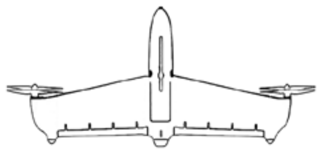
Unreliability and non–scalability of VTOLs



Tilt rotor axes reduce reliability of design



Extra engine reduces max payload weight



Tail-sitter is highly sensitive to wind speed at take-off and landing

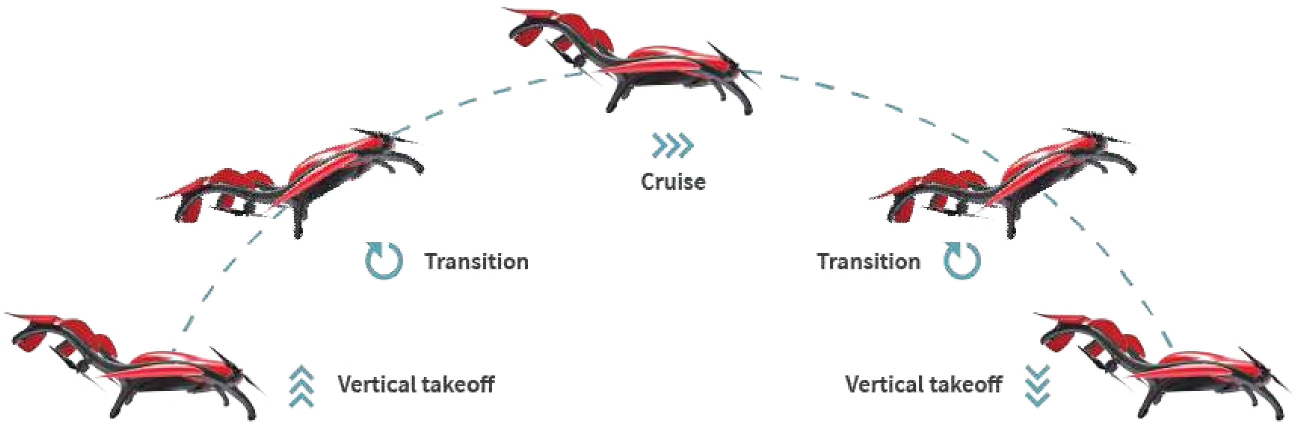
In a 2019 study, several VTOL concepts were evaluated, and researchers pointed out several downsides of the existing solutions: “The types of platforms that include tilt-rotor, tilt-wing, rotor-wing, and tail-sitter suffer from poor aerodynamic performance, complex control systems and transition maneuvers, unstable vertical flight and susceptibility to disturbances in transitions. ” In addition to these conclusions, any moving parts on an aircraft lead to increased part wear and stress, thus adding to the expenses related to fixes and maintenance. Also, moving mechanisms increase the risk of potential technical malfunction.

In the paper, it was also noted that **the technology to look for, is quadrotor fixed-wing hybrid UAVs,** as these aircrafts “have no tilting mechanism, have smooth transitions and advantages in control, manufacturing and maintenance costs and are recently receiving increasing attention and interest.”

FIXAR TECHNOLOGY

FIXAR combines a sophisticated mix of software and hardware technologies as well as industry's best practices and in-depth know how's to serve market's request for a more reliable industrial drone solution. Due to the **hybrid aerodynamic design, the FIXAR configuration combines the main advantages of a fixed-wing and a multirotor scheme.**

The 4 fixed rotors generate lift for vertical take-off, then the aircraft smoothly transitions to an airplane mode. The rigid wing of the aircraft generates lift due to the drone's forward airspeed, thus saving energy for longer flights and heavier payloads. At the same time, the rotors mounted on a FIXAR's frame enable great maneuverability on the turns. A combination of multirotor drone and fixed-wing aircraft, complemented by Fixed Angle Rotors principles, is part of FIXAR's intellectual property.



Also, since the FIXAR 007 requires twice as fewer flights to complete the task, it naturally reduces the wear of drone components, time spent on technical checks, as well as the amount of crew's working hours.

Proprietary Autopilot software and in-depth understanding of aircraft aerodynamics give FIXAR a unique opportunity for **fast and efficient payload integration**. The software uses a unique mathematical algorithm for a stable and autonomous solution as it eliminates data security concerns of open-source platforms.

FIXAR **xGroundControl Software** is a closed-source mission planning software that allows to build and edit a fully autonomous fixed-wing VTOL drone flight missions and monitor it in real-time using 3D visualization.

An additional feature FIXAR has introduced is the FIXAR BlackBox, which is a **software and hardware system** designed for recording, collecting and analyzing aircraft's autopiloting logs. It consists of a built-in module that records all flight data into technical logs and LogExport software to further process these logs for your purposes, for example, for 3D terrain mapping.

All the previously described technologies give FIXAR the possibility to outperform other existing solutions. Notably, FIXAR employs a **best-in-class payload capacity amongst compact size drones**: 1.6 m (5.25 ft) wingspan carries 2 kg (4.4 lbs) payload, making it the smartest choice for a variety of industrial applications in terms of cost efficiency and ease-of-use.

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FIXAR

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