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Research Article

An Innovatively Modern Manufacturing and Design of the Fixed-Wing UAV Drones

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Abstract:

This study presents the most common directions and manufacturing problems of the development of fixed-wing UAV systems and their various implementations, including military, civil aviation, ecology, and agriculture. A classification of these drones is provided and their features depend on the type of the drones. The review is primarily devoted to the problems arising when using these systems, possible ways to solve them, the opportunities to increase the efficiency and performance of such systems and concrete solutions. The study is intended to provide an overview of the development of modern drone manufacturing innovations and the rapid progress that can impact successful exploitation of uncrewed aerial vehicle (UAM) in several operating fields.

1. Introduction

Drones, or Unmanned Aerial Vehicles (UAVs), are lately becoming prominent in the military, civil aviation, environmental, agriculture and many other fields. The military deploys them for reconnaissance, surveillance, attack and other missions, freeing them up to make those operations more efficient and to keep pilots out of harm's way. Within civil aviation, UAVs can be utilized for border control, search and rescue, environmental inspection and in countless other applications. In environmental work, UAVs are employed to detect forest fires, evaluate vegetation cover, manage air and water pollution, etc. Agriculture also looks at the UAV as an essential tool for the optimisation of field management, crop management, disease and pests recognition among other operations.Thus, it can be said that the relevance of UAVs in the modern world is continuously growing and their use will only increase in the future [1-3].

Until the beginning of the 21st century, unmanned aerial vehicles (UAVs) were mainly aircraft of aircraft type and military purpose. This is due to the fact that the electronics of those times were quite expensive and bulky. And the maintenance of such equipment could afford mainly only the military. Amateur aeromodelling was expensive and exotic, and a Quadro-copter was out of the question in the 1990s. Only with the appearance of affordable and fast enough microprocessors and miniaturized sensors based on new technologies, the first projects of autopilots based on them appeared. This made it possible to create multi-copters, as these vehicles are aerodynamically unstable and require constant electronic stabilization in flight. The development of multi-copters, in its turn, stimulated the development of flight controllers and by the early 2010s there was a mass distribution of drones among ordinary consumers and their increasing use in the civil sphere [4, 5].

The above review reveals the significant deficiencies of the fixed wing UAV drone. (Fig. 1) – a type of drones that have fixed wings, which makes them like aero-planes. The advantages of this type of UAV are resistance to wind gusts, long flight time, high payload capacity, and simple structure. The aim of this study focuses on the most recent manufacturing and innovative design of UAV drone.

Figure 1. *UAV with fixed wing*

2. Applications of fixed wing unmanned aerial vehicles

Fixed wing UAVs are used in a variety of applications and their range of use continues to expand. They can cover vast agricultural areas. Using multispectral cameras, these drones can monitor crops, analyses soil and assess crop yields. Drones can be used not only to monitor a crop, but also to regularly acquire data for further analysis (Fig. 2). In order to detect A current area of research includes new material and design methods for the construction of UAVs. These efforts are for the purpose of enhancing durability, reducing weight, increasing the structural strength or decreasing the noise therefrom. For example, researchers at UC Berkeley have developed a lightweight, self-healing material that would be perfect for UAVs. [6-9].

Figure 2. *Fixed wing UAVs in agriculture*

Modern agriculture today occupies a leading position in the rapid and successful introduction of new technologies. Among the most interesting and promising experts include the use of artificial intelligence and modern software, Big Data. However, there are factors that can significantly slow down the introduction of drones into the daily practice of agriculture [10, 11]:

1. Poor awareness of the benefits of drones and their capabilities. Many farmers are unaware of how drones can improve their operations and yields.
2. High cost of equipment at first glance. The initial investment in drones may seem significant, which discourages some farmers from purchasing them.
3. Difficulties in operation for some farmers. Although drones are becoming increasingly affordable and easy to use, some users may have difficulty operating them.
4. Frequent software updates, which requires extra effort and time from farmers to keep the drones up to date.

Fixed-wing drones are also used in geodesy and cartography. They draw precise and complete maps and plans of numerous districts, things and buildings. Environmental monitoring is also inseparable from UAVs, we can use UAVs for forest, water, air quality monitoring, pollution detection and environmental management. The capability for flight and accessing remote areas makes UAVs a useful aid for conservation. However, there are problems and disadvantages to using drones in environmental research:

- Imperfect databases. Information and training systems need to be created.
- The complexity of the on-board hardware complex.
- Expensive hard and software.
- Privacy and ethical issues. These are especially related to the observation of animals and the protection of their natural behaviour.
- Gaps in legislation. There are many restrictions in the use of drones, their registration and application.

Provided UAVs Fixed wing UAVs are suitable for surveying disaster-stricken, flooded or ruined areas, locating injured or missing people and providing necessary medical care or provide food.Fixed wing drones are also employed in military service for border control and military surveillance. Their fixed wings in the shape of propellers allow them to glide through the air for long distances with minimum energy thirsty effort. This content makes them invaluable for military observation [12].The development of the systems and facilities of the UAV complexes depend on their effective application in different operations. The question of prospects of building such complexes is of a great interest for specialists due to the potential and possibility Characterisation

Fixed Wing UAS are utilised usually for Long Range / long Endurance missions. They are mainly designed for specialized tasks such as reconnaissance, surveillance and pesticide spraying, as well as for other specific purposes.
The average flight time of most fixed wing drones is two hours. Up to 16 hours or more can be flown by gas-powered UAVs. The higher flight time and fuel efficiency make fixed wing drones ideal for long-range operations, but only where there is no need to keep it stationary in the air [13].
Other disadvantages of fixed wing drones include higher cost and the need for specialized training to control the flight. Getting a fixed wing drone into the air is not easy. It requires either a ‘runway’ or a catapult to steer a fixed wing drone on the desired course in the air. To land a fixed wing drone safely on the ground again requires a runway, parachute or net.
An aero-plane type UAV has supporting wings that provide lift and flight. They are controlled remotely or by computer. A UAV with a ‘mono-wing’ is considered the most functional [14].

3. Development and innovation

Modern UAVs are a science-intensive, high-tech field. Here we will review the main trends in the development and improvement of fixed wing UAVs.
JUMP™ from Arcturus (Fig. 3) is a vertical takeoff and landing system for Arcturus T-20 and T-16 fixed wing UAVs [15]. Attached to each wing are nacelles with vertical lift motors and rotors that provide vertical lift during takeoff and landing. The vertical lift engines are switched off when flying on the wings and the propellers are deployed longitudinally to reduce drag.

Figure 3. *Arcturus aircraft equipped with JUMP™*

A smooth transition to wing-based flight is provided by the Piccolo autopilot, utilizing Latitude Engineering's Hybrid-Quadrotor technology, and flight control is fully autonomous.
The Arcturus JUMP™ offers all the advantages of a quadcopter while retaining the greater range and endurance of a fixed wing aircraft. Arcturus aircraft (Fig. 3) equipped with the JUMP™ do not require special equipment to launch and do not need runways to launch or land. The JUMP™ can be easily transported and maintained by as few as two technicians, and once installed in the field, the JUMP™ can be ready for flight in less than 15 minutes.
In the work of [16] the aerodynamic efficiency and flight dynamics of a monoplane and a box-wing aircraft were studied at different parameters. The study showed that while the aerodynamic efficiency of monoplanes is higher in certain regimes, monoplane aircraft with a box-type wing perform better at high speed and at higher lift requirements. This configuration can suppress vortices at the wing tips. Flight dynamics analyses have shown that low aspect ratio box wings exhibit improved wind gust stability and stability in longitudinal and lateral dynamics.
Researchers from Sharif University of Technology in Iran have recently conducted a study [17], in which they examined the potential of flying robotic systems with a single wing, known as single-winged aerial vehicles. The researchers developed a single-wing aircraft design in which the vehicle is positioned perpendicular to the wing and outside the wing. This arrangement also makes the vehicle better balanced and easier to assemble. For the control, a cyclic control-like type of controller, which used to be installed in helicopters, has been further developed and tested to rotate the vehicle with precise control.
In [18], a comparison between three control strategies linear-qua dractic regulator (LQR), linear-qua dractic Gaussian (LQG) and non-linear control was introduced for the control of the pitch dynamics of fixed-wing UAVs. LQR has the merits of stability and robustness and LQG can deal with external disturbances efficiently. The research covers autopilot design, control laws modeling with MATLAB/Simulink system, which permits compare efficiency of using each method at speed, reliability and uptime. In their paper [18], novel control strategies are required to stabilize flight dynamics, then Gao et al [18] gives attention to longitudinal motion and controller design. A simulation was performed in the MATLAB/Simulink environment, and we concluded that with LQR/LQG, and non-linear control theory, it is possible to control the pitch angle of a fixed-wing UAV. The sensitivity to pitch angle was best for the LQG controller with interference, whose performance was otherwise poorest; LQR controller was the best without interference; overall the non-linear controller was

best.. The use of the non-linear control method achieved significant results, providing a very good match to the pitch angle output data. Further work on fixed-wing UAVs will focus on developing control systems for side flight dynamics and adapting navigation strategies for high wind conditions.

Various parameters, such as weight, material selection, and aerodynamic efficiency, are carefully considered during the design and manufacturing of UAVs. Therefore, research is also being conducted on the selection of structural materials. Basic materials such as carbon fiber, Kevlar, fiber-reinforced plastic (FRP), and resins are commonly used.

Along with traditional composite materials, carbon nanotubes can find wide applications in UAV manufacturing due to their amazing physical, electrical and chemical properties. In addition to forming lightweight structural components, they can be used to create tiny sensors, act as a resistive heater to de-ice aircraft wings, and provide shielding for sensitive electronics [20].

Special attention should be paid to hybrid UAVs. They combine the capabilities of aero-planes and multirotor drones (Fig. 4). During takeoff and landing, they use rotary or fixed propellers to create lift, and during flight – to move forward.

Among the main advantages of such drones are vertical take-off provided by additional engines, high speed and maneuverability, and a successful take-off weight to payload ratio. In addition, hybrid UAVs save motor energy resources, which makes them more efficient in long flights [21], [22].

But, there are drawbacks too. These include maintenance problems, reliance on weather that may hinder their usage and also the high cost associated with these technologies, rendering it potentially huge for their use in wider population.

Figure 4. *Hybrid VTOL Cargo Drone*

Figure 4 Among the aspects for which there is a pressing need for innovative work, the next generation: (a) Materials and design technologies of UAVs. This is required to make them lighter, stronger and more resilient, while also reducing noise on board. For instance, scientists at the University of California, Berkeley have engineered lightweight self-healing material that could be used to build sturdier UAVs. Built from a polymer, the 3D printing material possesses dynamic bonds, which allows it to transform from liquid to a solid and vice versa. The new material also has an unusual shape memory, which means it can be programmed and triggered to return to a particular form. The newly discovered family of materials (Fig. 5) made softer or harder by varying the number of the crosslinking molecules, thanks to researchers at the US Army [23].

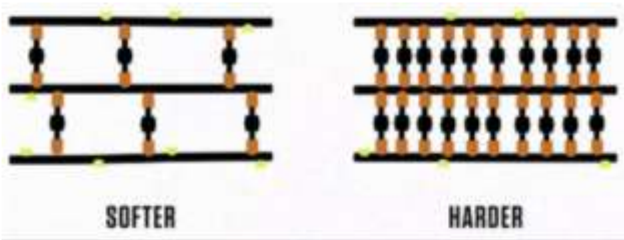

Figure 5. *Structure of molecules*

Another important area of research is the development of new sensors and payloads for UAVs. This will allow them to be used in a wider range of scientific applications, such as environmental monitoring, disaster management and search and rescue operations. For example, researchers at the Swiss A team of the Federal Insitute of Technology Lausanne has created a revolutionary drone-borne sensor that can record air and greenhouse gas emissions. Meanwhile, Axetris has also launched its compact LGD laser gas detection module, designed for methane detection. It’s also small scale so it could be integrated into drones.

Explicting then quickly started system integration on the basis of Axetris’ test equipment and performed first field tests for methane emission monitoring at biogas plants and measurement on LNG ships. We have successfully validated for them in the lab, the LGD Compact, comparing against state-of-the-art alternative technology. The analyzer demonstrated good performance, with detection limits at the sub-ppm levels, good linearity, and short response times both in controlled atmospheres and true operating environments.

Based on these findings, Explicit is already developing the LGD Compact to further trace more gases. Now, the Sensor Module can also detect

NH_3, CH_4/CO_2, and CH_4/C_2H_6, which are important gases in environmental management. This progress is in line with Explicit's overarching vision of broadening its range of sources of emissions for environmental monitoring across its portfolio.

Swiss researchers have also developed an innovative potato mini-planner and biodegradable sensors for forestry. The sensors' Its purpose is to scan the state of the ecosystem — for instance, near the forest floor — and then break down into ashes after it has done its job. Based primarily on raw potato starch and printed before use, the biosensor is carried on a glider. Connected to the sensor, the glider is only 1.5 grams and has a wingspan of 14 centimeters. In the test flights, the bio-glider attains a glide ratio of 6, which is to say it travels 60 meters horizontally from a launch height of 10 meters [25].

One of the most significant innovations in the development of UAVs are autonomous control systems that allow them to function without constant human control. These systems include high-precision navigation technologies such as GPS and differential GPS, as well as various sensors and transducers that ensure flight safety and the ability to adapt to changing conditions. Artificial intelligence is crucial for the sensor data handling, thus enabling autonomous decisions and routing optimizations of the UAVs [26]. And the communication system of UAVs also plays an important role in the effectiveness of UAVs. Application of modern data transmission technologies such as 4G and 5G significantly boost the speed and stability of communication, which is of vital significance for real time missions. Satellite communications systems are able to offer connectivity over long distances, and are considered to be essential in areas lacking ground networks such as search and rescue at disaster sites. [27]. Energy saving is also being increasingly considered in UAV designing, and thus unconventional mechanisms, such as solar panels (Fig. 6) and motors are used for lower operation costs and to extend battery life. With new technologies such as lightweight and flexible photovoltaic (PV), unmanned aerial vehicles (UAV) are already capable of effectively harnessing solar power.[28].A solar powered stratospheric aircraft has been constructed in New Zealand [29]. This aircraft establishes a new paradigm for ultra-high resolution aerial data acquisition that could revolutionize forecast and weather analysis in extreme weather, environmental monitoring and precision agriculture. SCT has been developed to be launched for gradual maiden flights in stratosphere (or at high altitude). With a 12.5-meter wingspan, it's described as weighting less than 40 kilograms and flying very high in the sky — above commercial airliners.

Figure 6. *Stratospheric solar-powered aero-plane.*

4. Conclusion

the age of unmanned aerial vehicles (UAVs) is giving us wings for innovation and the arrival of new technologies. To design and develop them, knowledge of sectors like aerospace, electronics, software and artificial intelligence, among others, would have to be closely integrated. This establishes an ideal environment for cooperation and knowledge transfer between diverse industries and research groups.

Moreover, applications of UAVs can make significant improvements of the efficiency and economic benefits in many industries. They can minimize the labor cost of endoscopic instruments, improve the accuracy and efficiency of work and the safety and quality of work.

In brief, advances in UAV and their applications to various aspects of life are essential milestones for society. They offer new possibilities, and allow for problems that were once intractable, or limited, to be addressed. Drones have the ability to totally transform our lives and help to promote progress in many of the segments [31].

The capabilities and functions of Unmanned Aerial Vehicles are constantly being enhanced with the advent of technology. Modern UAVs are furnished with sophisticated navigation systems, autonomous piloting capabilities and high-performance sensors that allow them to fly in high-risk areas and to carry out missions under adverse conditions. However, UAVs are also faced with several problems, for example flight control is difficult, the take-off and the landing space is larger, and the influence of wind and other meteorological condition on aerostatics.

Overall, fixed wing UAVs occupy an important place in UAV technology and applications due to their efficient flight characteristics and wide range of applications. With the continuous development of technology, they will show great potential and

value in more and more fields. Advances in UAV technology not only improve their functionality but also raise important ethical and safety issues that require an integrated approach.
The current key areas of development for unmanned aerial vehicles (UAVs) to improve their performance, functionality and applications are:

- increasing autonomy and flight duration.
- development of multi-rotor systems with high maneuverability and vertical take-off and landing capability.
- improved automation systems.
- use of lighter and stronger materials.
- development of hybrid systems.

However, it should be noted that the prospects for the development of UAVs and their complexes are far from being limited only to the above-mentioned directions. Rapid technological progress and constant research suggest that there will be new and innovative directions of development of this technology.

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- **Ethical approval:** The conducted research is not related to either human or animal use.
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