

## CONSTRUCTIVE ADVANTAGES OF ELECTRIC-POWERED FIXED-WING RECONNAISSANCE UNMANNED AERIAL VEHICLES

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**Abstract.** Electric-powered fixed-wing reconnaissance unmanned aerial vehicles (UAVs) have gained significant attention due to their efficiency, low acoustic signature, environmental friendliness, and operational flexibility. This article analyzes the constructive advantages of electric propulsion systems in fixed-wing reconnaissance drones, focusing on aerodynamic efficiency, structural simplicity, energy utilization, stealth characteristics, maintenance requirements, and mission adaptability. The study highlights how electric propulsion enhances endurance, reliability, and suitability for modern intelligence, surveillance, and reconnaissance (ISR) missions. Comparative analysis with internal combustion engine-based UAVs demonstrates that electric fixed-wing platforms provide superior performance in tactical and strategic reconnaissance applications.

**Keywords:** electric UAV, fixed-wing drone, reconnaissance UAV, electric propulsion, UAV design.

**Annotatsiya.** Elektr dvigatelli samolyot tipidagi razvedka uchuvchisiz uchish apparatlari (UUА) yuqori samaradorligi, past shovqin darajasi, ekologik tozaligi va ekspluatatsion moslashuvchanligi tufayli katta e'tiborga sazovor bo'lmoqda. Ushbu maqolada elektr yuritma tizimlariga ega samolyot tipidagi razvedka dronlarining konstruktiv afzalliklari aerodinamik samaradorlik, konstruktiv soddalik, energiyadan foydalanish, yashirinlik xususiyatlari, texnik xizmat ko'rsatish va vazifaga

moslashuvchanlik nuqtai nazaridan tahlil qilinadi. Tadqiqot elektr dvigatel razvedka dronlarining zamonaviy razvedka, kuzatuv va monitoring vazifalaridagi ustunligini ko'rsatadi.

**Kalit so'zlar:** elektr UUA, samolyot tipidagi dron, razvedka droni, elektr yuritma, UUA konstruksiyasi.

**Аннотация.** Разведывательные беспилотные летательные аппараты самолетного типа с электрическим двигателем привлекают значительное внимание благодаря своей высокой эффективности, низкому уровню шума, экологичности и эксплуатационной гибкости. В данной статье рассматриваются конструктивные преимущества самолетных разведывательных БПЛА с электрической силовой установкой с точки зрения аэродинамической эффективности, конструктивной простоты, энергоэффективности, скрытности, технического обслуживания и адаптивности к миссиям. Исследование показывает, что электрические БПЛА самолетного типа обладают значительными преимуществами для современных разведывательных и наблюдательных задач.

**Ключевые слова:** электрический БПЛА, беспилотник самолетного типа, разведывательный БПЛА, электрическая силовая установка, конструкция БПЛА.

**Introduction.** Unmanned aerial vehicles have become an essential component of both military and civilian reconnaissance missions. Advances in lightweight materials, battery technology, avionics, and autonomous control systems have enabled UAVs to perform complex tasks with high reliability and minimal human intervention. Reconnaissance UAVs, in particular, require long endurance, stable flight characteristics, low detectability, and high-quality sensor integration.

Electric-powered fixed-wing UAVs represent a unique intersection of aerodynamic efficiency and clean propulsion. Unlike rotary-wing or internal combustion-powered UAVs, electric fixed-wing platforms rely on optimized lift-to-drag ratios and efficient energy consumption to achieve extended mission durations.

These characteristics make them particularly suitable for intelligence, surveillance, and reconnaissance (ISR) missions over large geographical areas.

This article aims to analyze the constructive advantages of electric-powered fixed-wing reconnaissance UAVs from an engineering and operational perspective. Emphasis is placed on structural design principles, propulsion efficiency, endurance optimization, and comparative performance analysis.

*Design Philosophy of Electric-Powered Fixed-Wing UAVs.* The design philosophy of electric-powered fixed-wing reconnaissance UAVs is centered around maximizing aerodynamic efficiency while minimizing structural weight and energy consumption. Fixed-wing configurations inherently offer higher lift-to-drag ratios compared to rotary-wing platforms, enabling sustained forward flight with reduced power requirements.

Electric propulsion systems eliminate the need for complex mechanical components such as fuel pumps, exhaust systems, and gearboxes. This simplification allows designers to focus on lightweight airframes constructed from composite materials such as carbon fiber-reinforced polymers and foam-core sandwich structures. The integration of modular components further enhances maintainability and scalability.

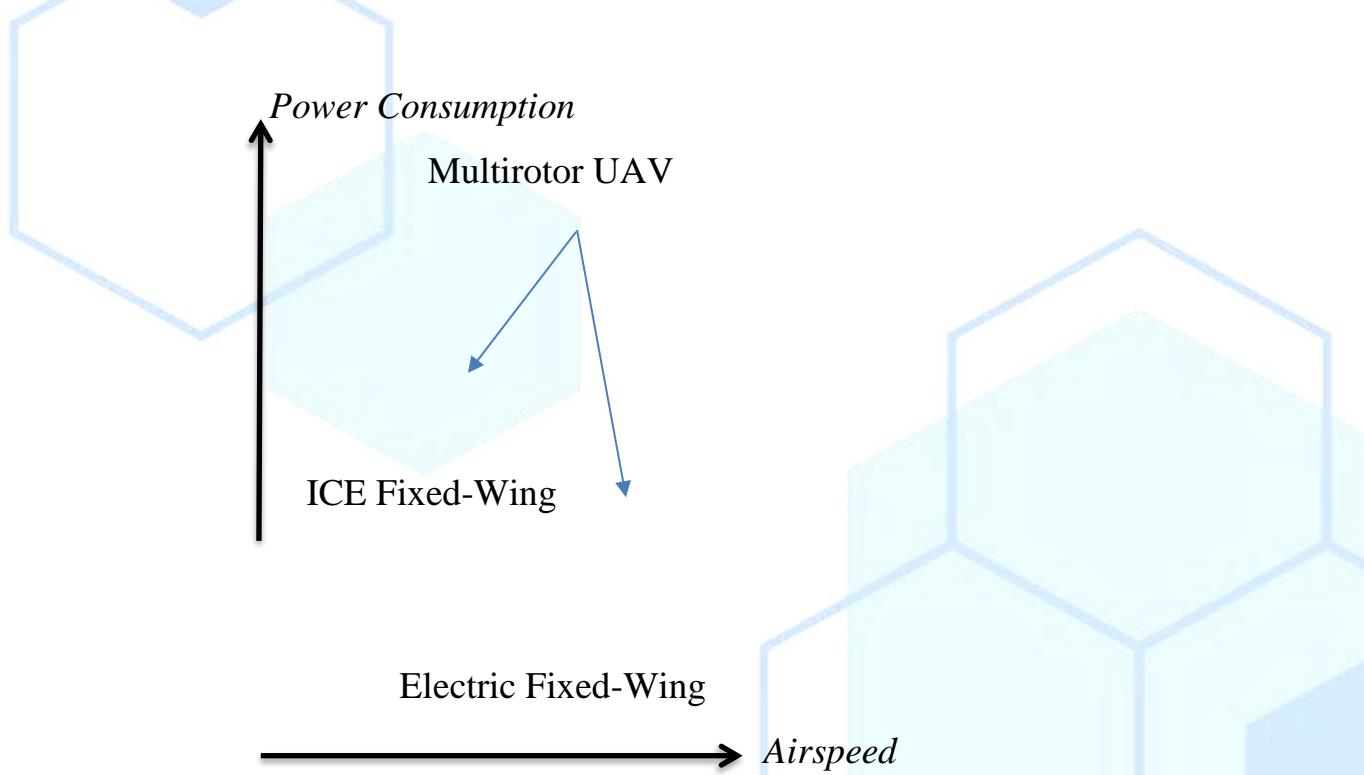
The absence of fuel-based propulsion also enables more flexible internal layouts. Batteries can be distributed along the fuselage to optimize the center of gravity, improving flight stability and control responsiveness.

*Aerodynamic Efficiency and Flight Performance.* Aerodynamic efficiency is a fundamental advantage of fixed-wing UAVs. Electric-powered reconnaissance UAVs are typically designed with high-aspect-ratio wings, laminar flow airfoils, and optimized wing loading. These features reduce induced drag and enhance glide performance.

The continuous thrust provided by electric motors allows for precise speed control and smooth transitions between flight regimes. Unlike internal combustion engines,

electric motors deliver maximum torque at low rotational speeds, improving takeoff performance and climb efficiency.

The following conceptual graph illustrates the relationship between power consumption and airspeed for different UAV types:



The graph demonstrates that electric fixed-wing UAVs achieve lower power consumption at cruise speeds, which is critical for long-duration reconnaissance missions.

**Propulsion System Advantages.** Electric propulsion systems offer several constructive advantages over internal combustion engines. The primary benefit is high energy conversion efficiency, often exceeding 85%, compared to 25–35% for small gasoline engines. This efficiency directly translates into longer flight endurance for reconnaissance missions.

Another significant advantage is the low acoustic and thermal signature. Electric motors generate minimal noise and heat, reducing the likelihood of detection during covert surveillance operations. This characteristic is particularly valuable in military and border monitoring applications.

Electric propulsion systems also require less maintenance due to fewer moving parts. The reduced mechanical complexity enhances system reliability and lowers lifecycle costs.

**Structural Design and Materials.** The structural design of electric-powered fixed-wing UAVs emphasizes lightweight yet robust airframes. Composite materials play a crucial role in achieving high strength-to-weight ratios. Carbon fiber composites provide excellent stiffness and fatigue resistance, while foam and honeycomb cores reduce mass without compromising structural integrity.

The elimination of vibration-intensive combustion engines allows for more delicate sensor payloads to be integrated without extensive isolation systems. This results in improved data quality from electro-optical, infrared, and synthetic aperture radar sensors.

The modular construction approach enables rapid assembly, repair, and component replacement. Wings, fuselage sections, and payload bays are often designed as interchangeable modules, enhancing operational flexibility.

**Endurance and Energy Management.** Endurance is a critical parameter for reconnaissance UAVs. Electric-powered fixed-wing platforms excel in this area due to efficient energy management strategies. Advanced lithium-polymer and lithium-ion batteries provide high energy density, while emerging solid-state and lithium-sulfur technologies promise further improvements.

Energy-efficient flight profiles, including optimal cruise speeds and altitude selection, significantly extend mission duration. Solar-assisted electric fixed-wing UAVs further enhance endurance by harvesting renewable energy during daylight operations.

The following table presents a comparative endurance analysis:

UAV Type	Typical Endurance	Noise Level	Maintenance
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Electric Fixed-Wing UAV	6–20 hours	Very Low	Low
ICE Fixed-Wing UAV	4–12 hours	High	High
Multirotor Electric UAV	0.5–1.5 hours	Medium	Medium

The data indicates a clear endurance advantage for electric-powered fixed-wing reconnaissance UAVs.

***Payload Integration and Sensor Performance.*** Reconnaissance missions demand high-quality sensor payloads capable of collecting accurate and reliable data. Electric-powered fixed-wing UAVs provide stable flight platforms with minimal vibration, enhancing sensor performance.

The availability of electrical power simplifies the integration of advanced sensors and onboard processing systems. Power distribution systems can be optimized to support simultaneous operation of multiple payloads without significant performance degradation.

Payload bays are typically designed with standardized mounting interfaces, allowing rapid reconfiguration for different mission objectives. This adaptability is essential for multi-role reconnaissance operations.

***Comparative Analysis with Alternative UAV Configurations.*** A comparative analysis highlights the constructive advantages of electric-powered fixed-wing UAVs over other configurations. Compared to multirotor UAVs, fixed-wing platforms offer significantly longer endurance and greater operational range. While multirotors excel in vertical takeoff and landing capabilities, their high energy consumption limits their suitability for extended reconnaissance.

In comparison with internal combustion engine-powered fixed-wing UAVs, electric platforms demonstrate superior stealth, lower operational costs, and reduced environmental impact. Although battery energy density remains a limiting factor, ongoing advancements continue to narrow the performance gap.

The following qualitative comparison summarizes key differences:

Feature	Electric FW	ICE FW	Multirotor
Endurance	High	Medium	Low
Acoustic Signature	Very Low	High	Medium
Maintenance Complexity	Low	High	Medium
Operational Cost	Low	High	Medium
Stealth Capability	High	Low	Medium

***Environmental and Operational Benefits.*** Electric-powered UAVs contribute to reduced environmental impact by eliminating direct emissions and fuel spills. This advantage is particularly relevant for civilian reconnaissance applications such as wildlife monitoring, agricultural surveying, and disaster assessment.

Operationally, electric UAVs can be deployed with minimal logistical support. The ability to recharge batteries using portable generators or renewable energy sources enhances mission sustainability in remote areas.

The reduced noise footprint also enables operations in urban or environmentally sensitive regions without causing significant disturbance.

***Challenges and Future Development Trends.*** Despite their advantages, electric-powered fixed-wing reconnaissance UAVs face several challenges. Battery energy density remains the primary limitation affecting payload capacity and endurance. Weather sensitivity, particularly to strong winds and precipitation, can also impact mission reliability.

Future development trends focus on hybrid propulsion systems, advanced energy storage technologies, and improved aerodynamic designs. Artificial intelligence-based flight control and swarm coordination are expected to further enhance reconnaissance capabilities.

The integration of advanced materials and additive manufacturing techniques will likely lead to lighter, stronger, and more efficient airframes.

**Conclusion.** Electric-powered fixed-wing reconnaissance unmanned aerial vehicles offer substantial constructive advantages in terms of aerodynamic efficiency, endurance, stealth, and operational cost-effectiveness. Their simplified propulsion systems, lightweight structures, and modular designs make them highly suitable for long-duration reconnaissance missions.

Comparative analysis demonstrates that electric fixed-wing UAVs outperform multirotor and internal combustion-powered platforms in key reconnaissance parameters. While technical challenges remain, ongoing technological advancements continue to expand their operational potential.

As battery technology, materials science, and autonomous systems evolve, electric-powered fixed-wing reconnaissance UAVs are poised to play an increasingly dominant role in both military and civilian intelligence-gathering operations.

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