

Developing a Commercial Model for High-Altitude Cleaning Using Drones in the Context of China's Low-Altitude Economy: A Case Study of Yunnan Kexing UAV General Aviation Company

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Abstract: As a strategic emerging industry prioritised for development in China, the low-altitude economy serves as a key driver for fostering new forms of productive capacity, with drones acting as the core vehicle for its practical application. The provision of high-altitude cleaning services utilising drone technology represents a new business model born from the integration of traditional service industries with the low-altitude economy. This paper takes Yunnan Kexing UAV General Aviation Co., Ltd. as its case study and, in the context of the broader domestic low-altitude economy, explores the logic behind the construction and implementation pathways of the UAV high-altitude cleaning business model. By analysing the company's current operational status and project implementation processes, the study summarises the model's distinct drivers of new forms of productive capacity, with drones serving a key advantage in technological innovation, operational efficiency, and market expansion, identifying three key innovative features: intelligent equipment upgrades, standardised operational procedures, and diversified service offerings. The study also highlights existing industry challenges, including inadequate policy support, inconsistent technical standards, and a lack of regulatory frameworks, whilst proposing targeted optimisation strategies and comprehensive implementation plans. The research confirms that the UAV high-altitude cleaning business model offers both economic and social value, capable of enhancing urban environmental management whilst fostering deep integration between the UAV industry and traditional service sectors, thereby demonstrating significant development potential. The findings of this study provide a theoretical basis and practical reference for the design of business models by similar enterprises, thereby contributing to the sustainable and healthy development of the low-altitude economy.

Keywords: Low-altitude economy, UAVs, high-altitude cleaning, business model, Yunnan Kexing UAV.

1. Introduction

1.1. Research Background

In recent years, China's low-altitude economy has entered a phase of rapid development, having been designated as a strategic emerging industry and playing an increasingly vital role in economic transformation and industrial upgrading [1]. The low-altitude economy relies primarily on drones and light aircraft, with business operations spanning multiple sectors including agricultural plant protection, infrastructure inspection, logistics and delivery, ecological conservation, and emergency rescue. Thanks to their manoeuvrability, rapid response times, controllable costs, and high data accuracy, drones are widely used in scenarios such as natural resource management, disaster prevention and mitigation, and urban operations and maintenance. They are particularly suitable for high-risk operational areas that are difficult for humans to access, thereby creating the technical conditions for the transformation and upgrading of traditional high-risk service industries such as high-altitude cleaning [2].

From a policy perspective, the state has continuously introduced supportive policies to promote the development of the low-altitude economy, and a framework of relevant regulations and standards is gradually being established, creating a favourable environment for the drone industry. However, domestic drone regulation currently still follows traditional aviation management models, with a regulatory logic centred on risk prevention and control. There is a lack of flexibility in areas such as operator supervision, scenario

management, and business innovation, which is incompatible with the diversified, scenario-based development needs of the low-altitude economy [3]. Issues such as a lagging regulatory framework and poor institutional coordination have become the primary obstacles to implementing and promoting emerging UAV business models.

Against this backdrop, high-altitude drone-based cleaning services have emerged as a new direction in the low-altitude economy. Yunnan Kexing UAV General Aviation Co., Ltd. was one of the earliest enterprises in China to enter this sector, taking the lead in integrating UAV technology with high-altitude cleaning services to establish a mature and viable business model. A case study of this enterprise can objectively validate the feasibility of the UAV high-altitude cleaning model, clarify the pain points in the industry's development, and define future directions, whilst also providing a representative case for the research and practice of new business models within the low-altitude economy.

1.2. Significance of the Study

Amidst the global trend towards green and low-carbon development, urban environmental management and ecological conservation have become key priorities for development across regions. Traditional high-altitude cleaning relies on manual suspended operations, which not only pose high safety risks and incur significant labour costs but also suffer from low operational efficiency. The application of UAVs to high-altitude cleaning can effectively reduce labour input and mitigate safety hazards, whilst shortening operation cycles and lowering energy

consumption and carbon emissions, thereby aligning with the principles of green development [4–5].

From a theoretical perspective, current domestic research on the low-altitude economy and UAV technology is largely concentrated on hardware R&D and technical applications, whilst research into business models for the specific niche of UAV high-altitude cleaning remains relatively underdeveloped, and the relevant theoretical framework still requires refinement [6]. By conducting a case study centred on a representative enterprise, this paper aims to address this research gap, enrich the theoretical framework for cross-sectoral business models in the low-altitude economy, and promote theoretical exchange among the low-altitude economy, the UAV industry, and the environmental services sector.

In terms of practical value, this paper dissects Yunnan Kexing's operational model, workflows, and profit-making methods, providing a clear illustration of UAV applications in urban high-altitude cleaning scenarios and further validating the practicality and promotional value of this business model. Furthermore, the solutions to identified issues and the proposed strategies for promotion outlined in this study can serve as a reference for governments in refining industry policies and for enterprises in planning related business operations, thereby driving the extension of UAV technology into more public service sectors and contributing to the overall development of the low-altitude economy.

1.3. Current State of Domestic and International Research

The low-altitude economy has now become a hot topic in academic research. Existing studies generally agree that UAVs are a core pillar of the low-altitude economy, with widespread applications across sectors such as agriculture, forestry, transport, and environmental protection, and that their technological advantages drive the continuous expansion of the low-altitude economy [1–2]. Some scholars have suggested that the iterative upgrading of UAV technology has not only achieved breakthroughs in product performance but has also driven the coordinated development of upstream and downstream industrial chains, accelerating the full-chain deployment of the low-altitude economy [4].

In the field of industry regulation, several researchers have pointed out that China's current drone management system, which evolved from the traditional aviation management framework, is unable to keep pace with the rapid innovation of the low-altitude economy; mechanisms such as industry credit assessment, legal safeguards, and airspace management all require further refinement [3, 8]. Other scholars, drawing on international regulatory experience, have proposed that the domestic low-altitude economy requires establishing a dedicated standards system and management regulations. Furthermore, existing literature highlights that issues such as UAV communication standards, spectrum management, and cross-industry application specifications remain unstandardised, resulting in a lack of unified regulatory frameworks for industry development [23].

A comprehensive review of existing research reveals significant shortcomings at the current stage: firstly, there is an overemphasis on technology at the expense of commercial aspects, with few systematic studies on business models for UAV application scenarios; secondly, research perspectives tend to be narrow, with insufficient exploration of the cross-sectoral integration of UAVs with traditional service

industries [28]. Therefore, conducting research focused on the business model for high-altitude cleaning using UAVs and analysing industry challenges and development pathways through case studies holds a strong practical necessity.

1.4. Research Content and Methodology

Against the broader backdrop of the low-altitude economy, this paper focuses on the construction, operation, optimisation, and promotion of business models for high-altitude cleaning using UAVs. Taking Yunnan Kexing UAV General Aviation Co., Ltd. as the core case study, the study analyses the technical suitability, operational logic, and market prospects of this business model. The study is divided into three main sections: the first defines core concepts such as the low-altitude economy and the high-altitude cleaning business model for UAVs, whilst outlining the relevant theoretical foundations and technical underpinnings; the second analyses the company's business model, project implementation pathways and the effectiveness of model innovation through a case study; the third, grounded in the industry as a whole, proposes business model optimisation schemes and strategies for comprehensive promotion.

This study primarily employs literature review and case analysis methodologies. By reviewing relevant domestic and international literature, a theoretical analytical framework is established; through field research and data collation, the actual operational situation of Yunnan Kexing is analysed in depth, summarising its technical characteristics, operational model, and innovative experience. Concurrently, by integrating research findings on synergy between new energy and the industrial chain, the developmental patterns of the high-altitude drone cleaning business model are explored, ensuring the research's comprehensiveness and rigour.

2. Theoretical Foundation and Conceptual Definitions

2.1. The Concept and Development Logic of the Low-Altitude Economy

The low-altitude economy refers to all economic activities conducted within low-altitude airspace using various low-altitude aircraft, such as drones and helicopters, encompassing multiple sectors including logistics and transport, agricultural production, environmental monitoring, emergency rescue, and urban services [10]. Today, the low-altitude economy has been elevated to a national-level strategic emerging industry. It is characterised by a long industrial chain, a wide geographical reach, and a strong capacity to drive industrial development. It is capable of effectively revitalising regional economies and promoting the optimisation and upgrading of industrial structures.

The development of the low-altitude economy relies on three core drivers: technology, policy, and the market. At the technological level, continuous upgrades to drone flight control systems, positioning technology and communication networks provide the hardware infrastructure for low-altitude operations [12]; at the policy level, reforms to airspace regulations, airworthiness certification and industry support policies are being progressively implemented, continuously optimising the industrial development environment; at the market level, diverse demands from sectors such as urban governance, rural development and industrial operations and maintenance are continually expanding the application scenarios of the low-altitude economy. These three elements

complement one another, jointly driving the sustained growth of the low-altitude economy and creating the conditions for the emergence of drone-derived service models.

2.2. Key Components of the High-Altitude UAV Cleaning Business Model

The business model for high-altitude drone cleaning comprises four core elements: technology, service, operations, and profitability, with their synergy ensuring the business's stable operation.

Technology forms the foundation: by relying on high-precision positioning, intelligent control, and remote transmission, UAVs can operate reliably in complex environments such as buildings, bridges, and power facilities, accurately identify contaminants, and complete cleaning tasks. Technologies such as GNSS positioning and image recognition are key to ensuring operational safety and effectiveness [13].

The service element is central: this model primarily provides cleaning services for high-altitude surfaces, including the external walls of high-rise buildings, large bridges, and power equipment. Compared to traditional manual methods, it offers the advantages of high safety, rapid response times, and flexible service provision. Furthermore, it can leverage intelligent dispatch platforms to integrate resources and enhance service quality.

Operational elements provide the foundation: This sector requires integrating the entire industrial chain, encompassing equipment R&D, aerial operations, technical maintenance and support, and post-operation logistics. By leveraging industrial chain synergy to reduce costs and improve efficiency, enterprises must possess dual capabilities in both technological integration and market operations.

Profitability is the safeguard: Revenue is primarily derived from direct cleaning service fees, whilst channels such as value-added data services and government environmental subsidies can also be explored. A diversified revenue structure enhances the business model's resilience to risk and its market competitiveness.

3. Case Study of Yunnan Kexing UAV General Aviation Co., Ltd.

3.1. Company Overview and Business Model

Established in 2018 and headquartered in Kunming, Yunnan, Yunnan Kexing UAV General Aviation Co., Ltd. is a high-tech enterprise specialising in the research, development, production and scenario-based application of unmanned aerial vehicles (UAVs). Leveraging the advantages of Yunnan's complex and diverse geographical environment, the company has deeply engaged in the low-altitude economy sector. Its operations span multiple sectors, including high-altitude cleaning, agricultural monitoring, emergency rescue, and equipment inspection, and it has accumulated solid technical expertise in UAV flight control, hardware modification, and data processing [16].

The company adopts a development model of "in-house R&D combined with external collaboration", continuously optimising UAV hardware performance and software systems, with a particular focus on overcoming challenges such as flight stability and endurance in complex environments. In terms of business strategy, in addition to core operations such as the sale of complete UAV systems and after-sales maintenance, high-altitude cleaning stands as its signature

service. The company has undertaken numerous high-altitude cleaning projects for urban buildings, municipal bridges, and industrial facilities, effectively reducing labour costs and enhancing operational efficiency. Concurrently, the company is actively developing an integrated model that combines "UAVs, artificial intelligence, and big data," establishing an intelligent operations and maintenance platform to drive the upgrade of its business towards intelligent and integrated solutions.

In terms of its position within the industrial chain, Yunnan Kexing operates as a technology and application service provider in the low-altitude economy sector, aligning with the industrial synergy framework of "equipment manufacturing – operational services – infrastructure – digital supervision – application scenarios". Its practical experience in the high-altitude cleaning sector also serves as a reference model for domestic drone enterprises seeking to expand into public service applications.

3.2. Implementation Pathway for High-Altitude Cleaning Projects

During the implementation of high-altitude cleaning projects, Yunnan Kexing has developed a standardised and intelligent implementation process. In terms of hardware, the company utilises a combination of multi-rotor and fixed-wing drones working in tandem, equipped with high-precision sensors and high-definition camera systems. By integrating AI image recognition technology, the system automatically identifies the location and type of pollutants and intelligently plans cleaning solutions [19]. This comprehensive process significantly reduces manual intervention, achieving automation in high-altitude operations.

In terms of software management, the company has independently developed a drone dispatch management platform capable of automatically planning flight routes according to mission requirements, monitoring the status of aircraft in real time, and optimally allocating equipment resources. Concurrently, the company has collaborated with major research institutions to optimise the drones' wind resistance, endurance and operational stability for complex regional environments such as high-altitude, high-wind and high-rainfall areas, thereby continuously enhancing the equipment's environmental adaptability [20].

In terms of project collaboration, the company proactively engages with local governments, environmental protection departments, property management firms and industrial entities, conducting operations in strict compliance with local environmental standards and safety regulations. For large-scale cleaning projects such as municipal bridges and iconic urban buildings, the company works with regulatory authorities to formulate implementation plans, ensuring full documentation and compliance throughout the process. This approach not only guarantees operational safety and cleaning effectiveness but also sets a benchmark for service standards within the industry.

3.3. Key Innovations and Achievements in the Business Model

Technological convergence and innovation represent the most prominent feature of this model. The company has optimised its UAV communication network to resolve industry-wide challenges such as signal interruptions during high-altitude operations and data transmission delays, ensuring the stable operation of multi-drone coordinated

missions and laying a solid technological foundation for the scalable development of its business [22]. Concurrently, the company has integrated multiple resources to combine high-altitude cleaning with services such as urban environmental management and emergency inspections, creating an integrated low-altitude service solution that establishes a differentiated competitive advantage.

At the market level, through long-term operations, the company has built up a stable client base encompassing municipal authorities, property management firms and industrial enterprises. By providing customised cleaning services tailored to different client needs, the company has expanded its service portfolio and enhanced customer loyalty. The application of UAV technology has effectively reduced overall operational costs; coupled with the continuous optimisation of resource allocation, the company's overall operational efficiency has steadily improved.

At the societal level, this model has fundamentally transformed the operational paradigm of traditional high-altitude cleaning, significantly reducing the incidence of safety accidents during high-altitude work and driving the transformation and upgrading of the environmental services sector. Simultaneously, the expansion of the business has stimulated synergy across upstream and downstream industries, including drone manufacturing, communications services and data analysis, thereby injecting new momentum into the local low-altitude economy. Currently, Yunnan Kexing's operational model is replicable and is poised to become an industry benchmark, driving the widespread adoption of drones in the field of urban public services.

4. Model Optimisation and Promotion Strategies

4.1. Directions for Model Optimisation

Taking into account the current state of the industry and corporate practices, the business model for high-altitude cleaning using drones can be optimised across three dimensions: technology, market and the industrial chain.

On the technological front, efforts should continue to advance the intelligent upgrading of UAVs, optimising autonomous navigation, dynamic route planning, payload capacity and endurance, so that the equipment can better adapt to complex operational scenarios involving different climates and building types; by leveraging artificial intelligence algorithms to achieve autonomous control throughout the entire operation, operational costs can be further reduced and operational efficiency enhanced [24].

At the market level, the industry currently faces issues such as service homogenisation and price competition. Enterprises need to establish a differentiated service system, launching customised solutions for different scenarios such as high-end commercial buildings, municipal facilities and industrial equipment; simultaneously, they should expand revenue channels by developing value-added services in conjunction with green finance and environmental protection policies, thereby broadening profit margins and enhancing the stability of the business model.

At the industrial chain and policy level, efforts should be made to promote in-depth collaboration between equipment manufacturers, technology service providers, operational enterprises and industry associations to build a comprehensive industrial ecosystem, thereby further reducing costs through resource integration. Proactive engagement

with government departments is required to address development shortcomings through policy support, providing institutional safeguards for the long-term operation of the model.

4.2. Implementation Pathways and Policy Recommendations

The commercial model for UAV high-altitude cleaning possesses strong replicability, but nationwide promotion still requires overcoming challenges such as regional environmental conditions, technical standards and regulatory policies.

Firstly, standardise industry technical and operational standards. Given the significant variations in topography, climate and urban layout across different regions of China, operational requirements differ from place to place. Industry associations should take the lead in formulating unified technical specifications, operational procedures and safety standards for high-altitude UAV cleaning, standardising equipment parameters, operational workflows and safety controls to ensure service quality and flight safety.

Secondly, policy support and institutional frameworks must be strengthened. The government should expedite the refinement of specialised regulations for the low-altitude airspace sector, clarifying airspace usage rules and the allocation of safety responsibilities for high-altitude UAV operations; establish dedicated R&D funds and demonstration projects; and implement preferential policies such as tax breaks and talent recruitment schemes to attract capital and talent to the industry; further, a robust regulatory system should be established to balance safety controls with business innovation, thereby deregulating and empowering this new business model [27].

Thirdly, implement regionally differentiated market promotion strategies. In economically developed cities with a high concentration of high-rise buildings, the focus should be on promoting high-end, fully intelligent cleaning services; in small and medium-sized cities and county-level areas, the emphasis should be on cost-effective basic cleaning services. Strengthen long-term cooperation with government environmental protection departments, urban investment companies and property management firms to build a diversified partnership network, gradually expand service coverage and promote the widespread adoption of high-altitude drone cleaning services.

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