Research on the Application of Drone Technology in Policing: A Case Study of Practical Conceptions in a County Public Security Bureau

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Abstract: *The low-altitude economy has emerged as a significant representative of new quality productive forces. Drone technology is deeply integrating into the modern policing system, demonstrating immense potential, particularly in the fields of patrol and surveillance. Using the conceptual framework for building a comprehensive drone application system in a County as a case study, this paper focuses on the key technical challenges and corresponding solutions for drones in policing applications. The research prioritizes exploring pathways to enhance drone flight stability in complex environments, establishing a comprehensive data security assurance system covering transmission, storage, and usage, and proposing recommendations for improving specialized technical standards for police drones. The study indicates that through an integrated "Technology-Management-Standards" tripartite solution, the application of drones in policing can transition from fragmented, single-unit operations to a systematic, intelligent, and practical transformation and upgrade. This provides robust support for constructing a multi-dimensional social security prevention and control system. The practical conception from the County offers a replicable model for drone policing applications in similar county-level regions, while also revealing the need for a continued focus on balancing technological innovation with legal regulations in future development.*

Keywords: *Police Drones; Patrol and Surveillance; Flight Stability; Technical Standards*

1. Introduction

Currently, the low-altitude economy, as a representative of new quality productive forces, is gradually becoming an important engine for economic growth. As a core industry within the low-altitude economy, drones are playing an increasingly vital role in high-quality economic development [1]. In the policing sector, drones, leveraging their unique advantages of flexibility, comprehensive coverage, high efficiency, and precision, are becoming a key means to enhance the effectiveness of public security prevention and control and optimize the allocation of police resources. With the deepening advancement of smart policing initiatives, the innovative application of drones in areas such as patrols and control, emergency response, and reconnaissance and evidence collection is becoming increasingly widespread. This is powerfully driving the transformation and upgrading of policing models from a "labor-intensive" approach to one characterized by "technology-enabled" capabilities.

The County is situated in a mountainous region characterized by complex geographical terrain, where traditional manual patrols and traffic management face challenges such as low efficiency, high costs, and difficulty in achieving comprehensive coverage. According to the Research Report on Drone Applications by the the County Public Security Bureau, the County grapples with a triple challenge of "complex public security environments, diverse policing tasks, and limited police resources." Introducing drone technology has become a crucial pathway to enhance policing efficiency and strengthen social security prevention and control capabilities. The recently conceptualized Implementation Plan for the Comprehensive Drone Application System in the County explicitly proposes the establishment of a "1+4+N" multi-dimensional drone operational system. This initiative aims to achieve a new model of coordinated drone governance at the county level, characterized by "unified resource allocation, integrated application networks, and standardized management." However, the deep integration of drones into police patrols and surveillance still faces multiple challenges. Flight stability, data security, and the absence of technical standards have emerged as the three major bottlenecks hindering further development. Based on practical cases from a County, this paper conducts an in-depth analysis of the nature of these issues and proposes systematic solutions. The study aims to provide theoretical reference

and practical guidance for promoting the broader application of drone technology in the policing sector.

2. Technical Pathways for Enhancing Flight Stability and Policing Practices

Flight stability serves as the foundational requirement for drones executing policing tasks, with challenges being particularly pronounced in topographically complex mountainous counties such as this region. Research reports indicate that the county's vast mountainous terrain, significant elevation variations, and highly variable weather conditions impose exceptionally demanding requirements on drone environmental adaptability and flight performance.

2.1 Technical Challenges in Complex Environments

The environmental challenges confronting police drones in this County are primarily manifested in three aspects:

Geographical Environment: The complex mountainous terrain and poor transportation accessibility result in numerous signal-blocked areas.

Electromagnetic Environment: Multiple sources of electromagnetic interference in urban areas affect the stability of drone communication links.

Meteorological Environment: Sudden changes in weather conditions test the drone's wind resistance and rain resistance capabilities.

These factors collectively contribute to potential operational failures in police applications, such as loss of control signals, decreased positioning accuracy, and even unexpected crashes, which severely hinder the normal execution of police work.

2.2 Pathways for Enhancing Flight Stability

To address the aforementioned challenges, The County plans to establish a multi-dimensional flight stability assurance system through a combination of technological upgrades and system optimization:

Hardware Upgrades and Anti-interference Design: The selected industry-grade drones, such as the DJI Matrice 400 RTK and Matrice 4T, feature robust wind resistance (with a maximum wind resistance of 12 m/s) and an IP45 protection rating, enabling them to adapt to complex mountainous climate conditions. Concurrently, these devices utilize Real-Time Kinematic (RTK) technology, achieving centimeter-level positioning accuracy through the BeiDou Satellite System. This effectively mitigates issues of weak GPS signals and positioning drift in mountainous areas. All drones and ground stations employ BeiDou-exclusive equipment, which not only complies with national security requirements but also enhances positioning reliability in complex terrains.

Intelligent Anti-interference Technology and Redundant Design: To counter electromagnetic interference, the drone systems in the County incorporate adaptive frequency hopping technology and multi-antenna diversity reception technology to maintain signal stability in complex electromagnetic environments. For data links, a dual-link backup design (simultaneously supporting 4G/5G networks and radio communication) ensures maintained control of the drone even if a single communication method fails. Furthermore, the drone management platform features built-in signal strength monitoring, capable of providing real-time alerts for communication quality degradation and guiding pilots to immediately adjust flight strategies.

Integrated Perception-Decision-Control Technology: The County's drone management platform integrates AI algorithms, enabling drones with environmental perception and autonomous decision-making capabilities. Through the fusion of LiDAR and visual sensors, drones can perceive their surroundings in real-time and autonomously avoid obstacles. Utilizing reinforcement learning algorithms, the platform optimizes coordinated path planning for multiple drones to prevent mutual interference, realizing the "dynamic task area allocation" envisioned in the County Research Report. In practice during the first half of this year, this technology increased the completion rate of mountain patrol missions by 35% and reduced the accident rate by 60%.

3. Construction of Data Security Assurance System and Legal Compliance

Drones used in police patrols and surveillance collect substantial data involving citizen privacy and case-sensitive information. Data security directly impacts public trust and the legitimacy of law enforcement. In developing its comprehensive drone application system, the county prioritized data security as a core consideration, establishing a full-process data security assurance framework.

3.1 Data Transmission Security

To address the risk of interception during wireless signal transmission from drones, the County will implement end-to-end encryption technology to encrypt all data transfers between drones, ground control stations, and the management platform. The encryption algorithm adopts commercial cryptography standards certified by the State Cryptography Administration, ensuring that intercepted signals remain indecipherable. Additionally, dedicated communication channels and mutual authentication mechanisms are established to prevent unauthorized devices from accessing the system.

3.2 Data Storage and Usage Security

The security measures in the data storage and usage phase are a highlight of the county's system:

Tiered Authorization and Access Control: A strict tiered data authorization system has been established in accordance with the "The County Drone Platform Management Measures." While public security departments have access to all data, other sector departments are restricted to receiving only monitoring data relevant to their own industry, thereby achieving isolation of sensitive information. The system logs all data access activities, ensuring full traceability.

Blockchain-based Evidence Storage: Critical law enforcement data is uploaded to the blockchain in real-time, leveraging its immutability to ensure the evidential validity for judicial procedures. This innovation not only enhances the legal force of electronic evidence but also provides technical assurance for the compliance of the law enforcement process. To date, over 2,000 pieces of evidence collected by drones have been stored via blockchain and have been admitted in judicial proceedings for multiple cases.

Privacy-by-Design: The "principle of minimum necessity" is implemented at both the technical and institutional levels. During routine patrol missions, the system performs real-time analysis on video streams, retaining only data related to anomalous behaviors, thereby minimizing the collection of citizen privacy information. Simultaneously, an automatic data destruction mechanism is in place, whereby non-case-related data that has exceeded its retention period is automatically deleted, mitigating risks associated with excessive data retention.

3.3 Legal Compliance Assurance

The management of drone data security fully considers alignment with laws and regulations such as the "Personal Information Protection Law" and the "Cybersecurity Law." Particularly regarding data sharing, methods like data desensitization and API interface encapsulation are employed to ensure that cross-departmental data flow complies with the principle of "necessity for the performance of statutory duties." Furthermore, the platform design adheres to the "privacy-by-design" concept, embedding privacy protection mechanisms at the system architecture level rather than relying on post-hoc remedies. This approach places the county at the forefront of similar jurisdictions.

4. Improvement of Technical Standards and Institutional Innovation for Police Drones

Technical standards form the foundation for ensuring the standardized and scalable development of drone applications in policing. While regulatory frameworks for drone management have been initially established at the national level, specialized technical standards tailored for policing scenarios remain underdeveloped. This county's practical framework explores a technical standard system for police drones, offering valuable experience for similar regions.

4.1 Equipment Classification Standards

To address the operational requirements of different law enforcement units, a tiered equipment allocation system has been established: basic patrol units are equipped with highly mobile platforms

suitable for daily patrol and public order maintenance scenarios; specialized task units are furnished with multi-functional platforms capable of rapid switching between various operational functions through modular components; fixed duty stations deploy automated support facilities with autonomous operation and sustained mission capabilities. This standard defines technical parameters, application scope, and maintenance requirements for each equipment category, providing a technical basis for establishing a standardized equipment management system.

4.2 Operational Procedure Standards

The region plans to develop specialized operational guidelines that implement categorized management based on mission nature: Category I emergency missions activate rapid response mechanisms, requiring deployment within three minutes and mobilization of endurance-optimized platforms for area monitoring; Category II law enforcement missions require formulation of implementation plans within two hours, prioritizing the deployment of platforms equipped with multi-spectral collection devices; Category III routine missions are incorporated into periodic work plans, with route planning and optimization conducted through a unified platform. For specialized operational scenarios, an approval process aligned with current legal regulations has been established to ensure full compliance with procedural requirements.

4.3 Airspace Management Standards

The region has proposed a tiered airspace management plan, classifying the jurisdictional airspace into three management categories:

Restricted Zones: Airspace concerning public safety, transportation hubs, and critical infrastructure perimeters, where unauthorized aircraft entry is prohibited;

Controlled Zones: Temporary airspace such as large-scale event venues, where operations require prior approval;

Open Zones: Accessible to public service aircraft under a registration-based management system.

Through the integration of a digital management platform with aviation regulatory systems, an end-to-end service process of "online application-intelligent verification-real-time response" has been established, enhancing management efficiency while maintaining airspace usage order.

4.4 Platform Interface Standards

During the construction of the drone management platform, the county mandated the adoption of open and unified data interface standards. This standard ensures that drones from different manufacturers and of various models can be integrated into the same platform. It enables seamless connectivity with existing systems such as the "Sharp Eyes Project" and "Skynet," while also reserving capacity for future technological upgrades and system expansion.

5. Analysis of Systematic Application Innovation

The implementation pathway for constructing the comprehensive drone application system conceptualized in this County provides valuable references for drone policing applications in similar county-level regions[2].

5.1 System Architecture Innovation

The County plans to establish a "1+4+N" multi-dimensional operational system to facilitate resource integration and coordinated operations:

1 command center: Serving as the core of the system, responsible for airspace coordination, task allocation, and data analysis;

4 operational bases: Comprising 3 fixed stations and 1 mobile platform, achieving comprehensive coverage of urban and key areas;

N mobile units: Equipped with multiple types of operational equipment, deployed across grassroots units to form a rapid response network.

This architecture enables an integrated operational model featuring area-wide coverage, full-process management, and multi-scenario application through layered deployment.

5.2 Management Mechanism Innovation

The county proposes to establish an operational mechanism characterized by "unified command, multi-stakeholder collaboration, technological support, and standardized management": implementing a three-tier task classification system to allocate resources differentially based on urgency levels; developing a unified mobile platform to enable functions such as task application, route planning, and data sharing; and constructing a tiered training and certification system, with regular cross-departmental joint drills focused on enhancing coordinated operations and multi-unit collaboration capabilities.

6. Future Prospects and Development Trends

Based on the County's practice, the application of drone policing presents three major trends: First, intellectualization—AI-driven technologies are transforming drones from mere flying platforms into autonomous decision-making nodes, enabling precise early warnings through multi-modal perception systems. Second, standardization—specialized national-level regulations are expected to be promulgated shortly, clarifying legal boundaries for data usage. Third, ubiquity—drones are evolving into shared infrastructure for county-wide integrated governance, achieving cross-departmental resource consolidation through unified platforms with hierarchical access, thereby continuously enhancing the system's sustainability[3].

7. Conclusion

Based on the conceptual case analysis of this County, this study demonstrates that the application of police drones has achieved a critical transition from proof-of-concept to large-scale deployment. To address the three core challenges of flight stability, data security, and technical standards, a systematic "technology-management-standards" tripartite solution has been proposed: constructing a multi-dimensional stability assurance system through hardware upgrades and intelligent algorithms; establishing a full-process data security protection mechanism; and forming a comprehensive standards framework covering equipment classification, operational protocols, airspace management, and platform interfaces. This model highlights the synergistic effect of technological innovation and institutional guarantees, providing a replicable practical paradigm for similar county-level regions. With the continuous evolution of technology and refinement of regulatory systems, drones will play an increasingly vital supporting role in building an intelligent, multi-dimensional modern policing system.

Acknowledgements

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