Benefits and barriers: An exploratory study of drone use and LiDAR technology application in UK policing

Bramble, J. and Lydon, D.

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Julie Bramble and David Lydon

Abstract

Uncrewed aerial vehicles (UAVs), commonly known as drones, have become essential tools in various policing tasks. This mixed method, exploratory study investigates their use and development in UK policing, in general operational and forensic contexts. Data were collected via *Freedom of Information Act 2000* (FOI) requests sent to 45 UK police services. The findings indicate that while drones can improve operational efficiency and situational awareness, their integration into forensic settings is hampered by excessive costs, insufficient training, and procedural and regulatory constraints. The study suggests that targeted policy reforms could enhance drones' utility, broadening police capabilities in routine operations and non-invasive complex investigatory work. Recommendations for policy and practice include developing standardised operating procedures, specialised training programs, cost-mitigation strategies, public transparency measures, and the piloting of programmes to develop advanced sensing (such as LiDAR) and emerging technologies. The paper provides insights for police agencies beyond the UK, aiming to advance their drone capabilities for both routine policing and forensic contexts.

Key words - LiDAR, UAVs, drones, clandestine graves, forensic archaeology.

Introduction

The integration of uncrewed aerial vehicles (UAVs), referred to as drones, has revolutionised surveillance, data collection, and operational efficiency across various sectors. In recent years, the UK police service, with around 400 drones (NPCC, 2024a), has recognised their

potential to quicken response times, provide situational awareness and responder safety assessments, and enhance investigations and operational tasks: with the National Police Chiefs' Council (NPCC) describing them as 'indispensable' (NPCC, 2024a:1). Drones are applied in many diverse police activities, including crime scene documentation, road traffic collision (RTC) investigation, searches, and missing persons incidents (College of Policing, 2023). Drones equipped with advanced sensing technology such as Light Detection and Ranging (LiDAR) have potential for challenging forensic archaeological tasks in policing, such as searching for clandestine burial sites, where traditional search methods, such as ground-penetrating radar (GPR) and manual field surveys are resource intensive, time-consuming, and invasive, potentially disturbing forensic evidence. LiDAR offers an effective and non-invasive alternative for complex forensic contexts (Risbøl and Gustaven, 2018).

This exploratory study applies a mixed method approach, applying thematic analysis and descriptive statistics to data obtained from Freedom of Information (FOI) requests, to investigate the operational deployment of drones across 45 UK police services, specifically focusing on their integration into general policing operations and forensic contexts. The research questions examine the benefits of, and the potential barriers, to their wider adoption, particularly the financial, regulatory, and operational constraints that affect their use. Additionally, the study aims to identify the potential of LiDAR-equipped drones to enhance forensic investigations, specifically in detecting clandestine graves, and the factors influencing their integration into policing practices. The study also explores how UK police forces are managing the procurement, training, and deployment of drones, assessing the extent to which they are fully equipped to leverage these technologies effectively.

The paper is structured as follows: a literature review to contextualise drone usage in UK policing, particularly advancements in forensic archaeology and the role of drone technology. Additionally, the literature review identifies the technological progress and existing barriers

to drone integration in various policing contexts. The methodology and method section details the approach applied, including the use of FOI requests for data collection and process for data analysis. The findings establish key areas concerning drone deployment by police services. The discussion highlights the benefits and barriers to drone use in general policing operations and forensic contexts. Finally, opportunities for future developments and recommendations for optimising the development and use of drone technology (including LiDAR) in policing are considered.

Literature review

This research study addresses a significant gap in the available literature on a rapidly evolving area of police use of technology. There is a lack of published academic research in this area, specifically mapping drone use and current developments in UK policing. It is here, where the paper makes an original contribution.

Drones have emerged as a flexible, cost-effective solution for large-scale aerial-based searches. Police services in the UK have adopted them for tasks such as crime scene documentation, search and rescue, missing persons operations, and road traffic incident analysis (Sabri et al., 2023). Drones equipped with high-resolution cameras and thermal imaging have proved particularly useful in missing persons cases and for providing aerial overviews of complex crime scenes (Evers and Peters, 2018). Rix (2017) highlighted that while 25 UK police forces were using drones for various purposes, very few had deployed them in forensic contexts such as clandestine burial detection. A lack of standard operating procedures (SOPs) for forensic deployments, insufficient police training, and the cost of specialised equipment may help explain this gap in usage. Additionally, from the current workstreams reported upon by NPCC, the UK police service appears unclear about the full

capabilities of drones in forensic archaeological applications (see College of Policing, 2023; NPCC, 2023a, 2024a, 2024b).

Forensic archaeology, which applies archaeological methods to crime scene investigations, has developed significantly since its inception in the 1970s (Blau and Ubelaker, 2016). It plays a vital role in excavating and recovering human remains, personal items, and other evidence at crime scenes (Alecto Forensics, 2024; Holland and Connell, 2016; Schultz and Dupras, 2008). Forensic archaeologists assist police in locating clandestine graves using traditional detection methods such as ground-penetrating radar (GPR), manual surveys, and cadaver dogs (McKinnon and Harrison, 2016; Rebmann et al., 2000). However, these methods are resource-intensive, time-consuming, costly, and risk disturbing evidence (Hunter and Cox, 2005). Additionally, challenging terrain, such as dense forests or remote areas, can reduce their accuracy (Berezowski et al., 2021; Blau et al., 2019; Nareddy, 2024).

LiDAR technology, introduced in the early 2000s, has proven transformative in forensic archaeology. By using laser scanning to generate highly detailed digital terrain models (DTMs), LiDAR detects subtle topographic changes that may indicate buried structures or clandestine graves, even in densely forested areas where visual detection is difficult (Schindling and Gibbes, 2014). Its capacity to capture detailed imagery without physically disturbing a site offers significant advantages in forensic work. Risbøl and Gustaven (2018) emphasise the benefits of LiDAR-equipped drones: flexibility, low flight altitude, a small laser footprint, and an extensive field of view. However, challenges arise with its cost, limited battery life, restricted area coverage, and the need for a line of sight between the drone operator and the drone (Risbøl and Gustaven, 2018).

Outside of policing contexts, there has been a shift toward using LiDAR sensors integrated with drone platforms (Davenport 2018; Risbøl and Gustaven, 2018). Advances in sensor

technology, battery life, and flight-control systems now enable high-resolution scanning at low altitudes, an approach well suited to detecting subtle topographical features commonly associated with clandestine graves (Harrison & Donnelly, 2020). Compared to traditional aerial imagery, LiDAR-equipped drones offer critical advantages where covert burials might go undetected by optical methods alone (Keaney et al., 2021). Beyond detection, repeat LiDAR surveys can track terrain changes over time, helping investigators assess whether a feature reflects recent disturbance or a stable formation (Davenport 2018). Although cost and regulatory factors remain limiting in some jurisdictions, rapid improvements in sensor affordability and portability continue to expand possibilities for forensic work (Errickson et al., 2020). UAV LiDAR is now considered one of the most promising technologies for detecting clandestine graves with minimal site disturbance (Harrison & Donnelly 2020; Keaney et al., 2021).

In the UK, commercial archaeology projects have previously successfully employed LiDAR for remote sensing, using it to survey large areas quickly and efficiently. *Wessex Archaeology*, for example, used LiDAR in collaboration with the Environment Agency for floodplain mapping, demonstrating its utility (Wessex Archaeology, 2008). Despite these benefits and its proven record elsewhere, LiDAR usage in policing remains anomalous. This may be attributed to factors such as the high cost of the hardware, the specialised training required to deploy it, and the complexity of processing and interpreting LiDAR data (Coptrz, 2023a, 2023b; Rix, 2017; Schindling and Gibbes, 2014).

There is growing recognition of the imperative for standardised operating procedures governing drone usage in policing. The NPCC has emphasised the importance of a national drone strategy to ensure consistent practices and reduce operational inefficiencies (NPCC, 2023). Currently, an ongoing programme of activity under the rubric of ‘Drones beyond visual line of sight’ (BVLOS) aims to standardise drone operations and develop operational

guidance, expected to be published in 2025 (NPCC, 2024b). This includes establishing a core data and performance monitoring function to demonstrate the value of drones in policing, creating an asset catalogue, and sharing best practices.

The UK regulatory landscape presents challenges for police operations. Although police have powers to deploy drones for policing purposes, the Civil Aviation Authority (CAA) imposes strict regulations that can restrict their scope (ANO, 2016; CAA, 2022, 2023). BVLOS flights, useful for extended search missions, large-scale surveillance, or covering difficult terrain, require specific authorisations. Under current regulations, operators must keep uncrewed aircraft within direct line of sight unless granted special BVLOS permission or operational authorisation (CAA, 2022, 2023). Such permissions typically involve defined airspace restrictions and robust control-and-communication systems to mitigate risks to other airspace users and the public (ANO, 2016; CAA, 2022, 2023). Consequently, BVLOS operations must be carefully planned rather than undertaken spontaneously, even in urgent scenarios where rapid deployment could save lives or preserve evidence. Drone flights near airports, populated areas, or restricted airspace may also demand further permissions or coordination (CAA, 2022, 2023). These requirements can impede the immediacy and flexibility of police drone deployments. A key aspect of the BVLOS programme is strengthening regulatory relationships to support authorisations for police drone activities while promoting a 'safety-first' culture (NPCC, 2024a, 2024b). Notably, from an operational perspective, the BVLOS programme does not specifically mention LiDAR or drone deployment in forensic contexts, focusing instead on situational awareness, response support, and health and safety in real-time policing incidents (NPCC, 2024a, 2024b). Such omission may prove to be a missed opportunity that needs addressing over the long term.

Methodology and method

The study is framed within an exploratory, mixed-methods design, chosen to capture quantitative and qualitative data associated with the use of drones and LiDAR technology in policing. Through the integration of thematic analysis with descriptive statistics, the study aims to provide a comprehensive understanding of real-world practices, current challenges, and emerging opportunities in this area of policing.

To operationalise the methodology, data were collected from 45 UK police services through structured *Freedom of Information Act 2000* (FOI) requests. These requests yielded two data types: quantitative data, analysed through descriptive statistics to identify the frequency and extent of drone operations and LiDAR usage; and qualitative data, subjected to thematic analysis to identify key themes, challenges, and operational practices in the deployment of these technologies. The following research questions are addressed:

1) How are UAVs currently applied in various police operational contexts, and what specific forensic challenges and needs exist for their use in detecting clandestine graves?

2) What operational, financial, and regulatory challenges influence the adoption of UAVs, particularly those equipped with advanced sensing technology?

3) What is the potential impact of LiDAR technology in enhancing forensic capabilities, specifically in identifying clandestine graves, and what factors affect its integration into UK policing?

4) How are UK police forces managing UAV procurement, training, and deployment practices?

Data collection

Data were collected by sending FOI requests to 45 Home Office approved police services across the UK (including England, Wales, Scotland, and Northern Ireland). FOI requests

provide statutory access to non-public official information. The researcher compiled a list of the 45 UK Home Office approved police services to be contacted by email, cross referencing it with the '*What Do They Know*' web-based FOI contact directory. The selection of cases was based on the researchers' judgment about which were most relevant to the research questions. This purposive sampling method ensured that the data collected provide meaningful insights specific to the context (Daniel, 2012). Data collection occurred between October 2023 and April 2024. The structured FOI request included the following questions:

1. Do you use UAVs (drones) at crime scenes? If so, for what types of scenes and how many times in the last two years?

2. Do you use your own UAVs, or do you subcontract UAV services from an external provider? If so, which company/body and what type of UAVs are used?

3. Have you ever used UAVs to search for clandestine graves or missing persons?

4. If the answer to any of the above is 'yes', what has been the financial cost (both internally and externally)?

5. How many staff members are trained to deploy UAVs, and what has been the cost of training?

Sample and response rate

Of the police services contacted (N=45), 31 provided responses to all the questions (68.8%), 3 provided partial responses (6.6%), others either refused due to the time and cost of searching for and collating data, or stated they did not hold the data requested (11.1%). Specifically, the response rate for each FOI question can be reported as: Q1 - 73.3% (n=33), Q2 - 75.6% (n=34), Q3 - 73.3% (n=33), Q4 - 73.3% (n=33), Q5 - 73.3% (n=33). It should be noted that the level of detail in the information provided by respondent forces differed across

the sample. However, the responses provided sufficient data for analysis to establish themes and trends. The inclusion of all Home Office police services of the UK ensures that the study provides a comprehensive overview of drone use across varied operational and geographical contexts.

Data analysis

Though the main analysis is based on qualitative data, there are quantitative elements to them that support the insights provided. The quantitative data primarily comprises descriptive statistics, including counts, percentages, averages, and ranges, collected through cross-sectional FOI responses. This data offers insights into usage, deployment frequency, training costs, and operational expenses, with a focus on aggregated, numeric, categorical, and descriptive information to identify trends and challenges relating to drone use. Consequently, the application of inferential statistics is unlikely to add substantial value, given the nature of the data (see Field, 2017; Silverman, 2006). The descriptive statistics, alongside thematic analysis, provide an appropriate approach to addressing the research questions (Heap and Waters, 2019).

Qualitative data were analysed using inductive thematic analysis, a method that involves identifying, analysing, and reporting patterns or themes (Braun and Clarke, 2006; Jackson and Bazeley, 2019). This approach was chosen because it allows for the exploration and generation of themes directly from the data, rather than fitting it into a pre-determined coding framework. The NVivo software application (version release 14) was used to manage, analyse and store the data. This software facilitated the coding process by allowing the researcher to ‘tag’ key segments of text and group them into thematic categories relevant to the research questions. The initial step involved line-by-line coding of FOI responses to become familiar with the data and note initial impressions. Each response was systematically

coded, with each representing a specific topic or issue raised by the respondent (e.g., training costs, frequency of drone deployment, use of external contractors). Once all data were coded, the codes were grouped into themes. These were then reviewed and refined by the authors to establish coherence and relevance to the stated research questions. This process is commonly used for thematic analysis of data using NVivo (Jackson and Bazeley, 2019).

Ethical considerations

Institutional approval[1] for the research study was obtained, ensuring that all research practices complied with ethical guidelines and legal obligations. All police service identities were anonymised, and any personal information inadvertently disclosed by respondents was excluded to protect the privacy of individuals and their organisations. Data were stored [2]securely and confidentially, with protected access restricted to the authors. This was in line with the ethics protocol mandating that researchers treat all data responsibly and in compliance with the UK General Data Protection Regulation (UK GDPR) (incorporated in the *UK Data Protection Act 2018* (as amended)).

Limitations

While the study provides valuable insights into the use of drones across UK Home Office approved police services, the use of FOI requests it is not without limitations. One is the variability in the quality of the data provided. Some respondents provided detailed information, including specific numbers of drone deployments and training costs, while others offered only basic data, declined or were unable to report certain details. This inconsistency in data quality could limit the generalisability of the findings. Additionally, the

[1] Cranfield University.
[2] FOI requests were sent and responses received by the institutions secure email system and accessed via the authors' authenticated login credentials. Data were then entered into the NVivo database provided by the university and hosted on its cloud-based server. The database was only accessible to the researchers via their login credentials and all files were password protected.

use of FOI requests poses challenges to the accuracy of the data provided, since it is mediated by the person(s) completing the responses. Public institutions may redact or exclude sensitive information, which can lead to missing data. The refusal of some to respond, due to cost restrictions, can further limits the completeness of the dataset.

It should be noted that this is an evolving aspect of policing and policing research, with several projects and strands of activity presently taking place (see College of Policing, 2023; NPCC, 2024a, 2024b), any research of this nature can only provide a 'snapshot' in time of drone usage. To minimise the impact of the limitations, where possible data were triangulated with already publicly available FOI request results, published on individual police force websites and the '*What Do They Know*' web-based repository (see What Do They Know - Make and browse Freedom of Information (FOI) requests portal). Despite the limitations, this study provides an original and comprehensive overview of the state of drone use by UK police services, particularly highlighting the potential for integration of advanced technologies such as LiDAR. The research provides an understanding of the benefits and barriers associated with drones in UK policing.

Findings and results

The data provided insights into trends: training, uses and deployment frequency, costs, and the challenges faced by police in integrating drones, including those equipped with advanced sensing (such as LiDAR), into general policing operations and forensic contexts.

Trends in drone use (2021-2023)

There was a reported increase in drone use among UK police services since 2017, when it was previously documented that 25 police forces were using drones for overt policing operations (Rix, 2017). Since then, from data received, drone adoption appears to have grown, with police deploying them for multiple purposes.

The most common uses cited included searches related to missing or vulnerable persons (81.8%), RTC analysis (involving road deaths) (45.4%), crime scene documentation and investigation (i.e., arson, burglary, sexual, homicide and crimes in progress) (69.6%), and crowd and public event monitoring (24.2%). While the deployment of drones in overt police work, such as monitoring protests, traffic incidents, and surveillance, was common, their use in forensic contexts was far less prevalent. Only three forces (9%) reported using drones specifically for forensic archaeology searches (i.e., ground disturbance and clandestine burial sites). None reported using LiDAR technology. Despite the recognition of drones as valuable tools, their potential has not yet been fully realised.

Number of deployments

The number of drone deployments over a two-year period varied across the forces who responded with sufficient detail for this question (n=24) (*M* = 1460, *Mdn* = 1070.5). Some (20.8%) reported fewer than 100 deployments, while one force reported 8,392 deployments over a two-year period, which was attributed to having a full-time drone team with specialist officers trained to deploy in a wide variety of operational contexts. The precise number of forces with dedicated drone teams is not known. Forces reported limited use for infrequent situations, such as monitoring drug-related incidents (6%), and providing aerial surveillance during firearms operations (15%).

Brand and type of drone

The responses (n=27) revealed that 79.4% of forces own their own drones. 29.6% reported these as being provided by the manufacturer *Dà-Jiāng Innovations Science and Technology Co., Ltd.* (DJI), with popular models including the Inspire 1, Phantom 4, and Mavic series. These drones were favoured for their reliability, ease of use, and affordability. For specific applications such as thermal imaging, only 1 reported using the DJI Mavic 2 Enterprise,

equipped with advanced sensing for night-time or low-visibility searches. Others (11.1%) partnered with local fire and rescue services or leased their drones (manufacturer/model were not reported). None reported having LiDAR capability in their drone fleet.

Staff numbers and roles

The number of trained drone operators varied across the sample. While some forces had between 10 to 20 trained operators (39.3% of responding forces), a minority reported more than 60 (9% of responding forces). All forces used police officers to operate drones. Some also involved non-warranted police staff in their drone operations (41.9%) (these are employees who are not sworn police officers). The precise roles were not established by the FOI request. The reduced involvement of non-police officers suggests they are an under-utilised resource, which might be more widely integrated into police drone operations.

Training and development costs

Training and development costs for drone operators were variable across the responding forces. Only 1 reported using in-house training (3%), suggesting that others relied on external provision. The reported initial training costs ranged from £249 to £1,750 per staff member (n=13 forces). Due to deficiencies in the level of financial information provided, average cost per drone pilot for their initial training, licensing and development is not known. One force reported that their in-house 'trainers' managed all drone training, aiming to reduce the financial burden associated with training multiple operators externally. However, several (29%) indicated that they lacked sufficiently detailed records of their training costs, demonstrating inconsistent tracking and budgeting for drone operations.

Cost of drones

The costs of maintaining and retaining drone capacity varied significantly across the forces. A minority (3%) categorised drone-related expenses as part of their general operational budget

and could not provide specific drone-related costs, while others (24.2%) provided partial information covering initial procurement, maintenance, insurance, and servicing costs. These ranged between £31,518.18 to £214,000.00 over two-years (*mean* £41,045.50 p.a.). It should be noted for the future that the cost associated with LiDAR-equipped drones is significantly higher than standard drone models. It is purported that the cost of upgrading to LiDAR technology would be in the region of £10,000 per unit, in addition to the data processing and storage expenses (Coptrz, 2023a, 2023b). Many police services acknowledge that the high initial investment and ongoing operational costs are substantial barriers to them adopting advanced drone technology (see Jackman, 2023).

Standard operating procedures

A striking finding is the variability in how police forces approached drone deployment. Only 1 reported having a fulltime drone team with clearly established procedures for how and when drones should be used (although this may have changed with the passage of time since data was collected). Most relied on limited and fragmentary information from the UK College of Policing and NPCC (see College of Policing, 2023; NPCC, 2024a, 2024b) and local force procedures. While the national policy and procedural arrangements are presently under development, the focus is on overt policing tasks, those for specific forensic application appears an omission. In the interim, the absence of guidance across all police services may be contributing to significant inconsistencies in drone usage.

Discussion

The findings demonstrate the increasing use of drones by UK police forces for various general policing tasks but highlight underutilisation in forensic application (particularly in the search for clandestine graves). This discussion explores the implications by analysing the trends, according to the benefits and barriers presented for general policing and forensic

application (particularly in utilising LiDAR technology). While some are common to both contexts, others are more specifically focused.

Benefits and barriers of drones in general policing

The findings suggest that drones have rapidly become valuable assets within UK police services, with many forces reporting thousands of deployments annually. Their operational versatility spanning missing persons searches, traffic collision analysis, and real-time monitoring of public events demonstrates how drones have enhanced situational awareness and expedited decision-making processes. Compared to aerial support provided by helicopters, drones are more cost-effective, can be deployed more swiftly, and capture high-resolution imagery and thermal data useful for both intelligence gathering and emergency responses. These advantages highlight the transformational impact that drone technology has had on day-to-day policing activities.

Regulatory and organisational challenges

Despite the clear operational benefits, several barriers impede the optimal integration of drones into policing. Primary among these are the Civil Aviation Authority (CAA) regulations, which strictly govern operations in urban areas and significantly restrict beyond visual line of sight (BVLOS) flights. Intended to ensure public safety, these regulations can delay urgent deployments and curtail the flexibility that drones might otherwise offer. The withdrawal of the CAA's emergency services exemption in 2022 (CAA, 2023) compounded these challenges by requiring case-specific authorisations for police deployments, thereby impeding rapid drone operations. Consequently, regulatory constraints can delay investigations and limit the operational utility of drones in both policing and forensic contexts.

Financial constraints remain a persistent challenge, particularly for smaller or more budget-limited forces. Although drones are cheaper to purchase and operate than helicopters or large-scale deployment of officers 'on the ground,' the costs of maintenance, insurance, and training can still be prohibitive. Some forces address these financial obstacles through shared service agreements, one example is a memorandum of understanding with local fire and rescue services, allowing joint access to drones for specific tasks without any single agency bearing all the associated costs. While the benefits of drones and LiDAR in forensic archaeology are demonstrable, several challenges have impeded widespread adoption. One of the primary barriers is financial cost. Although the price of drones has decreased in recent years, the cost of LiDAR technology remains high. Risbøl and Gustaven (2018) point out that the high initial investment, along with associated data processing and storage costs, can be a significant burden for public services with limited budgets.

Training and standardisation issues

Beyond the regulatory and financial concerns, inconsistencies in training and standard operating procedures (SOPs) hamper the potential for broader or more specialised drone deployments. While some forces have well-resourced and dedicated drone capability, others lack formal programmes and detailed records of training. This leads to highly variable skill levels across the country and complicates planning for future expansion of drone capabilities. Although the NPCC is in the process of developing a national drone strategy, widespread reliance on *ad hoc* SOPs contributes to uneven practices. In many police contexts, ranging from basic aerial reconnaissance to targeted forensic tasks, officers use drones based on local policy rather than standardised protocols. Greater national coordination could enhance consistency, improve inter-force collaboration, and maintain the integrity of information and evidence gathered during drone-assisted operations.

Benefits and barriers of drones with LiDAR capability for forensic applications

Whereas drones have become increasingly common in general policing operations, their forensic application especially involving LiDAR technology, remains underutilised. Only 6.6% (n=3) of surveyed UK police forces reported using drones for searching clandestine graves, despite the complexity of such investigations and the promise of non-invasive aerial methods. LiDAR-equipped drones can generate high-resolution digital terrain models (DTMs) and penetrate dense vegetation more effectively than conventional drones, making them uniquely valuable in detecting subtle ground disturbances associated with concealed burials. Beyond clandestine grave detection, LiDAR may also be useful for detailed crime scene documentation in challenging terrains, as it provides precise, three-dimensional data without physically disturbing potential evidence. These advantages could dramatically improve investigative speed, accuracy, and overall efficiency in forensic archaeological and other specialised forensic contexts.

Financial and technical barriers

The high cost of LiDAR equipment and the associated software infrastructure forms the most significant barrier to its wider adoption by police forces. LiDAR systems are expensive to procure and maintain, and they also generate large volumes of raw data requiring advanced processing hardware, long-term data storage solutions, and specialist software licenses. As such, many forces find the initial set-up and recurring costs prohibitively steep.

Equally as challenging is the specialised expertise required to operate LiDAR systems and interpret the resulting data. Unlike standard drone imagery, LiDAR outputs require sophisticated geospatial analytical capabilities, including a thorough understanding of Geographic Information Systems (GIS) and advanced geophysical data interpretation. The vast amounts of information generated during LiDAR surveys, for example, require specialist

expertise to analyse effectively. Without adequate training, police services struggle to make sense of the data obtained, potentially leading to missed opportunities for evidence collection (Schindling and Gibbes, 2014). Most police forces do not currently maintain such expertise 'in-house,' thereby relying on external partners, such as academic institutions or private-sector specialists, which can further inflate costs and complicate operational planning, leading to inconsistent usage and over-reliance on external experts or commercial providers (Davenport, 2018; Donnelly and Harrison, 2020; Errickson et al., 2020; Jackman, 2023; Marino and Trombino, 2019; Pringle et al., 2012; Schindling and Gibbes, 2014).

Regulatory and organisational constraints

The adoption of LiDAR-equipped drones is hindered by the same CAA regulations that limit general policing drone operations (especially BVLOS). For thorough surveys, BVLOS capabilities are often necessary, making CAA approvals more complex and time-consuming. This regulatory environment can deter forces from investing in LiDAR technology, given the uncertain timelines and constrained flight parameters. Moreover, the lack of national guidance on LiDAR-specific forensic applications adds to the hesitancy. Police forces may be reluctant to allocate substantial budgets without clearly defined protocols or best practices identified.

Toward future developments

Emerging technologies may provide additional benefits for both general policing operations and forensic settings. AI-driven LiDAR data analysis could streamline interpretation by automatically identifying relevant patterns, reducing the time and expertise needed to interpret data. Autonomous drones equipped with LiDAR could be used to conduct systematic surveys with minimal human intervention, increasing feasibility in remote or hazardous areas. Additionally, combining extended reality (XR) with LiDAR drone

technology could create immersive real-time data experiences. XR can render drone-collected data into detailed 3D visualisations for virtual exploration, enhancing situational awareness for first responders and benefiting training and research through realistic simulations. Although these innovations are emergent, they represent a future direction for police services seeking to maximise drone utility and apply LiDAR technology. In the UK, this area of activity could be further developed under the NPCC's Science and Technology Strategy service lines and horizon scanning (see NPCC, 2023).

Recommendations

To optimise drone use in policing, and to facilitate future developments, the following five recommendations are proposed to police leaders and policymakers.

Develop standard operating procedures (SOPs)

Establishing clear, consistent, forensic-focused SOPs is essential for effective drone deployment, particularly in sensitive tasks such as clandestine grave searches and crime scene documentation. SOPs should include protocols for using drones in both forensic and non-forensic applications, clear data processing standards, and alignment with Civil Aviation Authority (CAA) safety regulations. To support this standardisation and practical accessibility, police services could consider developing a dedicated mobile application that provides real-time access to SOPs, regulatory guidelines, and operational updates. Inspired by such existing emergency response tools such as the Joint Emergency Services Interoperability Principles (JESIP) and 'Know Your Chemicals' (KYC) apps, a similarly customised mobile application for drone operators would centralise critical information, streamline operations, and ensure compliance with national standards, enhancing both efficiency, compliance, and safety.

Invest in specialised training

To address the technical expertise gap, police services should develop a set of competencies and implement standardised training programmes that cover both basic and advanced drone systems, including technologies such as LiDAR. Training should encompass not only operational skills but also interpretative abilities for complex data analysis, especially for applications involving Geographic Information Systems (GIS) and forensic indicators in LiDAR data. Utilising police staff, such as crime scene investigators (CSI), for drone operations would enhance resource efficiency by combining their forensic expertise with advanced technological applications. Additionally, interdisciplinary collaboration with academic institutions could enhance training resources, giving police forces access to advanced analytical support and shared technical infrastructure. The UK College of Policing in conjunction with NPCC could play a key role by developing a national learning platform for drone operations, or standardising access to external training providers, ensuring consistent and scalable training across forces.

Implement cost mitigation strategies

The financial constraints remain a major barrier to adopting advanced drone technology. Police services should consider conducting cost-benefit analyses and pursue resource-sharing models, such as joint procurement agreements, mutual aid, regional 'hub' arrangements for advanced drone equipment, and inter-agency partnerships with other public services (e.g., fire and rescue, mountain rescue). These collaborative strategies may reduce the individual financial burden on police forces (and their partners), while providing greater access to advanced technology like LiDAR. Pilot programmes for emerging technologies, such as AI-driven data analysis and autonomous drones, would also allow police forces to evaluate cost-effectiveness and practical benefits before full adoption. Through such programmes, police services can assess the costs and requirements of innovative technologies in a controlled,

experimental setting, providing insights to inform future procurement and budgeting decisions.

Enhance public transparency and engagement

As drone technology expands within police operations, maintaining public trust through transparency and engagement will be essential. For example, while drones may improve general policing and forensic capabilities, public perception around their use, particularly in surveillance and data collection, could attract mistrust if not thoughtfully managed. Police services should develop community consultation and engagement, and clear communication strategies that outline drone usage guidelines, operational ethics, and data privacy protections, particularly for situations that involve sensitive investigative work. Regular publication of operational data and public information sessions could reassure communities of the responsible and ethical use of drones. Extending current research on public trust in forensic science (see Kapageorgiadou et al., 2024) to include drone technology could inform these transparency initiatives; by involving the public in discussions about drone use in forensic contexts, police services could build stronger community relations and garner support for future technology integration. Independent oversight of drone usage policies and practice, may also help address ethical concerns, ensuring transparency and demonstrate public accountability.

Establish pilot programmes for emerging technologies

To explore the full potential of drones, police forces should consider pilot programmes for advanced technologies like AI-driven data analysis, autonomous drones, and extended reality (XR) applications integrated with LiDAR. AI-driven analysis could streamline data interpretation, automatically identifying topographical anomalies or forensic indicators, reducing analysis time and the need for highly specialised expertise. Autonomous drones

could enable systematic, remote surveys in inaccessible or hazardous areas with minimal operator intervention, improving feasibility and safety in complex investigations. XR technology could allow investigators to conduct virtual explorations of crime scenes, enhancing situational awareness and providing realistic training simulations.

These pilot programmes, developed in collaboration with academic institutions, technology providers, and other agencies, would allow police forces to evaluate new capabilities in controlled settings. Such partnerships could facilitate the sharing of best practices and innovative solutions to policing problems, contributing to a national framework for optimising the use of advanced drone technology.

Concluding remarks

This exploratory study provided a comprehensive exploration of the current and potential use of drones, including LiDAR-equipped models in UK policing. Through analysis of the FOI data collected, the research has revealed significant variability in drone deployment, the operational and financial barriers faced by the police, and the limited, but promising role of drones and LiDAR in forensic contexts. Although drones have become a useful tool for various general policing tasks, their forensic application remains underutilised. The findings highlighted the importance of implementing standardised procedures, investing in specialised training, and pursuing cost-sharing strategies to overcome the challenges. As drone technology advances, alongside the science and technology ambitions of UK policing, adopting the recommendations outlined may contribute towards a more comprehensive future-focused approach to drone use.

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