WMP Drone Unit Benefit - Cost Analysis

Data Analytics Lab

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This study aims to understand the benefits provided by the operations performed by the drone unit. Costs are taken into account for staffing levels required to run the drone unit operationally. Benefits have been evaluated via a combination of costs of crime, and costs of police time.

NPAS (National Police Air Service) operations have also been considered and compared to drone operations where appropriate.

Contents

1 Introduction

This report aims to understand the relationship between the costs and the benefits of operating a drone unit as part of the West Midlands Police (WMP) operations; while also taking into account comparable operations conducted by the National Police Air Service (NPAS, police helicopter).

It aims to establish the types of operations which the drone team participated in, understand how successful they were when they were called to action, and to then quantify each operation in terms of a monetary benefit.

The detailed conclusions can be seen in Section 6, however, they can be summarised as follows:

- The drone unit costs WMP an average of £2,823 per day, when accounting for current levels of staffing
- Benefits calculated across operations totals £15,774,783
- This yields a benefit / cost ratio of 7.34.
- The total flight hours of the drone unit during the reporting timeframe was 881 hours. This can be reported as:
    - A benefit of £17,905 per flight hour
    - At a cost of £2,439 per flight hour
- The total number of operations for the drone unit for the reporting timeframe was 2,480. This can be reported as:
    - A benefit of £6,361 per operation
    - At a cost of £886 per operation

2 Methodology

This section will look to understand the sources of data for conducting the benefit / cost analysis of the drone unit. Section 2.1 evaluates the two main data sources which are used to track the activity of the drone unit. Section 2.2 gives an overview of the drone flight statistics, while Section 2.3 will look in more detail at the types of operations undertaken by the drone unit, and the statistics associated with each operation. Section 2.4 seeks to understand the relationships between the data sources and outcomes of operations.

2.1 Data Collection

The data detailing each drone flight are contained in two databases maintained by the drone operators. One database is provided by Centrix and details every time the drone completes a flight. This database is a legal requirement from the Civil Aviation Authority. This will be known as the *Centrix database*. The second database is a spreadsheet completed after the operations have finished and contains detailed information about each operation. This spreadsheet will be known as the *Detailed spreadsheet*. Both of the databases used in this analysis are input by the officers/pilots themselves, and it is noted that there are significant human errors found within the dataset in all fields. Therefore, during the data clean-up process, there were numerous results not used due to these errors (error examples include incorrect dates, typing errors, characters in the log number field etc.). Details about the data collection and cleaning process can be found in Appendix A.

The Detailed spreadsheet contains the important detail of each operation, but does not contain the outcome, it is therefore not possible to tell whether the use of the drone unit has been beneficial using this spreadsheet alone. The Centrix database contains the outcome of each operation, and so it is necessary to infer a link between records from the two databases. Doing this will allow us to infer the success of each operation category, which can then be used to calculate monetary benefits for the drone unit. The total number of records available for use from the Detailed spreadsheet was 2,480 incidents, selected when the flight time was greater than or equal to 1 minute (anything less than this was considered not relevant to this study).

When creating this link, the objective was to link the two through data contained on the central Controlworks (CW) database which is the Force's incident management system recording attendance and activity. The link was centred on the date of a drone operation, the location where the operation took place, and whether the resource allocation for an incident used a drone. It should be noted that, since the drone unit is a mobile activity team, it is unlikely that they attend an incident at the precise location that is listed in the incident log (they are more likely to take off from a nearby location, one street away), and therefore the full postcode match was not possible. In light of this, the postcodes listed in the Centrix database were converted to neighbourhood codes, and any postcodes collected from CW were also converted to neighbourhood codes. Further details are in Appendix A.

2.2 Drone Flight Statistics

From the period of 1st January 2020 to 31st January 2022, there are 7,021 recorded operations on the Detailed spreadsheet tracker. These are recorded when the drone team have been called to action, regardless of whether or not a flight took place. During this period, it has been found that 1,447 operations were cancelled while the drone team was

en route to an operation. These cancellations can happen for a number of reasons, most notably for when the drone has been requested to support the apprehension of a suspect and the suspect has been apprehended prior to the drone's arrival. By conducting a text based search on the notes contained in the Detailed spreadsheet, it is also noted that there were 140 occasions where the drone attended an operation, but was unable to fly due to weather conditions at the time.

In addition to what is contained in the Detailed spreadsheet, a search was conducted on logs contained in CW. The logs were searched to identify the number of times a drone was requested, but no drone was available. In the same time period as above, there are at least 879 instances were a drone has been requested but has not been able to attend. This non-attendance was down to a number of reasons such as having no drone on duty due to other operational responsibilities, or due to the drone already deployed on other operations.

2.3 Drone Operations

Drone operations are listed in both the Centrix database, and the Detailed spreadsheet. The Detailed spreadsheet contains a better understanding of the type of operation the drone team performed, however, these operations fall within the same categories as the topics in the Centrix database.

The operation category in the Centrix database is discussed in greater detail in Section 2.4. In order to learn and infer the outcome of each operation from the detail contained in Centrix, it was necessary to match the operations in the Detailed spreadsheet, with those in the Centrix database. This was done with a mixture of operations sharing the same name, and through consultation with the drone operators. For example, *Assist Arrest* does not appear in the Centrix database, however, the drone operators say that the operation would be almost identical to that of assisting with a Warrant, therefore the matched category is *Warrant (non-firearms)*. The same reasoning holds true for *Football* and *Events/Protest*. The categories from the Detailed spreadsheet and their corresponding topic from the Centrix database are seen in Table 1 below.

Within the Detailed spreadsheet, a single incident could belong to more than one category. Therefore, the order in which the operations are listed in the order which they were counted; meaning that all the *Search for Offender* incidents were counted and moved into a subset before counting the number of incidents for *Assist Arrest*, and so on. Furthermore, this would mean that if an incident was listed as both *Search for Offender* and *Assist Arrest*, it would be counted only as the former.

Table 1 - Operations captured in Detailed spreadsheet and equivalent from Centrix

Detailed Operation	Count	Equivalent Operation Centix
Search for Offender	702	Offender Search
Assist Arrest	70	Warrant(non-firearms)
Warrant Assist	101	Warrant(non-firearms)
Search for Misper	430	Missing Person
Thermal Task	837	Hydroponics
Crime Scene Task	43	Evidential/Crime scene
Football	24	Large Public event
Events/Protest	72	Large Public event
Recce	53	Information/Intelligence
Training	84	Pilot training
OP Guardian	64	Information/Intelligence
Total	2,480	

As is seen in Table 1 there is a large array of different operations which the drone team will attend and support with. However, it can also be seen that 77% of all operations are represented by Search for Offender, Search for Misper, and Thermal Task.

2.4 Outcomes of Operations

In order to understand the outcomes of the drone operations, we needed to establish the link between the Centrix database and the Detailed spreadsheet, using the process outlined in Appendix A. This resulted in 927 linked incidents, out of a possible 2,566. However, this meant that it was now possible to learn the probability of success for each operation type. Overall, the positive outcomes totalled 342 (36.9%) incidents, negative totalled 387 (41.7%), and unknown totalled 198 (21.4%) incidents. The outcome probability was calculated on the operation type from the label contained in the Centrix database. The probability of a positive outcome per operation type can be seen in Table 2.

In order to retain as many cases as possible, the positive outcome percentages from the matched incidents were compared to the positive outcomes from the whole Centrix database. If the distribution of positive outcomes (by different types of incidents) between the matched and unmatched samples is similar (within acceptable bounds), then the outcome of the drone operations could be inferred across to the unmatched samples in the Detailed spreadsheet where the operation belonged to the same or similar category. The comparative positive outcome distributions can be seen in Table 2.

As is seen in Table 2, the proportions between the matched incidents and the original incidents are comparable. In order to evaluate how comparable the two methods are, measures of similarity on the distributions can be made. This is done by measuring the

Jensen-Shannon Divergence (JSD)[1], which measures the similarity between two probability distributions, and returns a score between 0 and 1, with 0 being identical and 1 being maximally different. In the case of the two distributions seen in Table 2, the JSD score was 0.0149, meaning there was less than a 1.5% difference between the outcome of the matched and the original operation incidents.

With the knowledge that the two distributions are very similar, it is therefore possible to conclude that the outcomes per category can be inferred across from the Centrix database to the Detailed spreadsheet. This creates a much larger, legitimate data pool for which the benefit / cost analysis can be built.

Table 2 - Comparison of Positive Outcome Proportion for Matched and Original Operations

Operation	Matched Positive Count	Positive outcome matched	Total Positive Count	Positive outcome original
Surveillance	5	1.00	7	0.88
Firearms	6	0.75	11	0.58
Evidential/Crime scene	15	0.71	56	0.64
Public Relations	7	0.70	54	0.83
Pilot Training	9	0.69	110	0.77
Large Public Event	12	0.63	53	0.65
Warrant (non-firearms)	16	0.62	83	0.77
Contingency planning	3	0.60	16	0.70
Exercise	6	0.60	21	0.57
Other	24	0.60	98	0.56
Support partner agency	3	0.60	14	0.82
Information/Intelligence	68	0.52	271	0.56
Hydroponics (thermal)	82	0.38	246	0.38
RTC	1	0.33	2	0.29
Missing Person	36	0.25	87	0.20
Offender Search	42	0.20	125	0.22

Therefore, the outcome rate of drone operations on the Detailed spreadsheet is seen in Table 3, this will be the basis of calculating the monetary benefit of the drone operations[2].

[1] https://www.cise.ufl.edu/~anand/sp06/jensen-shannon.pdf

[2] It should be noted that there is not a distinct class for firearms.

Table 3 - Total incidents per operation from Detailed spreadsheet, with inferred outcome

Detailed Operation	Count of all Operations	Positive Outcome Rate
Search for Offender	702	0.22
Assist Arrest	70	0.77
Warrant Assist	101	0.77
Search for Misper	430	0.20
Thermal Task	837	0.38
Crime Scene Task	48	0.64
Football	24	0.65
Events/Protest	72	0.65
Recce	53	0.56
Training	84	0.77
OP Guardian	64	0.56

3 Benefit - Cost Analysis

This section will begin to build a picture of the costs and benefits associated with the drone unit. Section 3.1 will focus on calculating the benefit per operation the drone unit attended, while Section 3.2 will give an overview of the costs associated with running the drone unit in its current form. Finally, an overall benefit / cost of the drone unit, with several different breakdowns for consideration, can be seen at the end of the report in Section 6.

3.1 Benefit per Operation

The following subsection is broken down into different operations, such that different approaches to calculating the benefit for each operation can be followed. Following the justification for the monetary value of the benefit at a per incident level, the overall benefit per operation will be calculated as follows:

$$Benefit\ (£'s) = Number\ of\ Operations * Positive\ Outcome\ rate * Impact\ Factor * Value$$

$$Benefit\ (£'s) * Crime\ multiplier$$

Where *Number of Operations* is the number of operations in each sub group, *Positive Outcome rate* is the rate of success taken from Table 3, *Impact Factor* is the estimated (or calculated where possible) contribution the drone unit had on a positive outcome, and *Value* is the unit cost of the benefit. For some of the operations to be detailed below, there exists data from the Home Office on the multipliers of crime.

The Home Office published a report detailing the economic and social impacts of crime in the UK[3]. This is a report that takes into account not just the monetary value of a crime, but also takes into account the harm experienced and social consequences. The figures only consider crimes relating to individuals, but not crime as it impacts society as a whole. Where possible, these crime figures are used in this analysis. The multipliers of crime contained in the Home Office report ensure that the unit cost of crime reflects the cost of each crime committed, rather than each crime recorded by police. This is because not every crime committed is recorded by police, or in this case, an individual may have committed several previous crimes before being apprehended, increasing the overall cost of crime. It is worth noting that the figures provided in the Home Office report are from 2018, while these could be regarded as out of date, they are the most recent figures available.

3.1.1 Search for Misper

The search for a missing person is an event that can utilise significant resources from WMP in terms of officers and search time. Evidence from the drone team suggests that the use of a drone in the event of a missing person can significantly reduce the time and resource needed in such a search. A drone can cover a 1 sq./mile area in 12 minutes, whereas the same task on the ground would take multiple officers many hours, potentially exposing them to hazardous environments.

[3] The economic and social costs of crime

A 2013 study by Greene and Pakes[4] into the cost of missing person investigations in the UK found that 99% of missing persons are found alive, and 77% of missing persons are found within 16 hours, with only 3% lasting longer than one week. Each missing person investigation would have a policing cost of a minimum of £1,325.44, while a realistic case in their study cost £2,415.80. Taking the two values from their study and averaging them gives a cost of £1,870; this will be used as the policing cost in this benefit / cost analysis. However, this cost was calculated in 2013, using the Bank of England inflation calculator[5], this equates to a policing cost of £2,280 in 2021.

Following conversations with Subject Matter Experts (SME), it is understood that the drone unit would be involved very early in an investigation for missing persons. The earlier the missing person is located, the greater the monetary saving in police time and resources. Therefore, for events where the drone unit successfully located and contributed to the identification of a missing person, the monetary benefit is to be taken as £2,280 per incident.

Regarding the impact factor, given that the drone unit is likely to be involved in the initial stages of the investigation, it is assumed that the drone unit has a significant impact on the outcome of the investigation when the outcome is positive. It is therefore estimated that the drone unit would have contributed 80% to outcome of the operation.

Using the numbers listed in Table 3, the benefit calculation is as follows:

$$\underline{Total\ misper\ benefit = \ 430 * 0.2 * 0.8 * £2{,}280 = £156{,}860}$$

3.1.2 Search for Offender

The value drawn from the successful search for an offender is not a straightforward one. Since the individuals in question are offenders at large, the monetary benefit from their apprehension is directly linked to the crime which they are suspected of committing. Therefore, in the case of *search for offender*, a hybrid approach was taken. The matched samples were first linked back to CW, where they could be. By looking at CW, it allows us to understand, at a high level, what the incident was, whether that be theft of a motor vehicle, burglary, firearms offences, etc. Where possible, and where the cost of the crime values existed, the search for offender operations were broken up. Where the crimes were known and costed accordingly, they were removed from the overall list of search for offender.

Of the 702 search for an offender operation types, 382 were able to be linked back to CW. Of these 382, there were 6 crimes which had a corresponding Home Office crime cost. These 6 crimes were *Burglary (Residential), Burglary (Commercial), Theft of Motor Vehicle, Theft from Motor Vehicle, Domestic Incident,* and *Assault*. The breakdown of frequency and crime cost can be seen in Table 4. For calculation purposes, the rate of positive outcome will remain the same as the whole operation for search for offender.

As is seen in Table 4, the number of linked incidents that can also be linked with a Home Office crime cost total 105 records. Therefore, there remain 597 Search for Offender

[4] https://missingpersons.police.uk/en-gb/resources/downloads/missing-related-research

[5] Bank of England inflation calculator

records where the crime is not known, or an accurate cost cannot be associated with. After consultation with members of the drone unit, the activity for Search for Offender was very much the same as the activity as searching for a missing person. Consequently, for the remaining incidents of search for offender, they were valued at the same monetary value as searching for a missing person. This is likely to be an underestimate in terms of resource cost as, in general, the WMP resource response is greater for an offender at large, than it is for the early stages of a missing person investigation.

Table 4 - Cost of Crime for relevant search for offender operations

Crime	Count of all Operations	Positive Outcome Rate	Impact factor	Crime Multiplier	Crime Cost (2021 £'s)	Total Monetary Benefit
Burglary (Resi)	41	0.22	0.5	3.6	£6,875.00	£111,622.50
Burglary (Com)	33	0.22	0.5	1.0	£17,925.00	£65,067.75
Theft of Vehicle	9	0.22	0.5	0.8	£11,931.00	£9,449.35
Theft from Vehicle	5	0.22	0.5	2.6	£1,008.00	£1,441.44
Domestic Incident*	12	0.22	0.5	1.5	£3,258.00	£6,450.84
Assault**	5	0.22	0.5	2.6	£9,554.00	£13,662.22
Total	105					£207,694.10

* Domestic incident counted as Home Office crime Violence without Injury. This represents an underestimation since there would be a portion of Domestic Incidents which involve injury, however this is difficult to infer from the drone data.
** Assault incident counted as Home Office crime Violence with Injury.

Furthermore, given the resource response for searching for an offender is greater than when searching for a missing person, the impact factor of the drone unit is assumed to be lower than the impact for searching for a missing person, therefore, this will be assumed to be 0.5.

The remaining Search for Offender tasks obtained a monetary benefit of:

$$Misc.Search\ for\ Offender\ benefit = 597 * 0.22 * 0.5 * £2{,}280 = £149{,}730$$

$$\underline{Total\ Search\ for\ Offender\ benefit = £357{,}422}$$

3.1.3 Thermal Task

Following the counting procedure and hierarchy of drone operations in Table 3, since all *Search for Misper, Search for Offender,* and *Assist Arrest* have been removed from the count for thermal operations, the only thermal operations which remain are the operations for drugs and cannabis farm discovery. As has been discussed with the drone unit, the operations are usually planned operations and are completed following the report of community intelligence.

This drone use has a significant impact on crime and policing, since it is very difficult and requires significant police resource to find cannabis farms without the use of thermal imaging. When a positive indication of a farm is present, this information is used to gain a search warrant for police officers to enter the buildings in question.

The cannabis disposal team at WMP maintain detailed logs of the cannabis farms that they are asked to dispose of. Their logs are detailed by counting the number of plants seized in each operation. Figure 1 shows the distribution of plant seizures by WMP between 2010 and 2021. It is seen that the vast majority of seizures are between 1 and 500 plants, with some seizures up to 2,000 plants. It is noted that there were three seizures greater than 2,000 (2,500, 3,523, and 4,919 plants), however these have been excluded from the graph for presentation purposes. Over the time period between 2010 and 2021, there were a total of 3,592 seizure operations.

The impact factor of the drone on identifying cannabis farms and their subsequent seizures was estimated to be 0.2, details of which can be found in Appendix A.

The number of thermal flights performed by the drone unit was 837, with a success rate of 0.38. Therefore, the estimated number of successful drone flights was 318. The cannabis disposal team assign a baseline value of £1,000 per cannabis plant. This is to reflect the prospective street value of any harvestable cannabis, and to account for the different stages of growth for when plants are seized. This is a widely accepted figure, nationally.

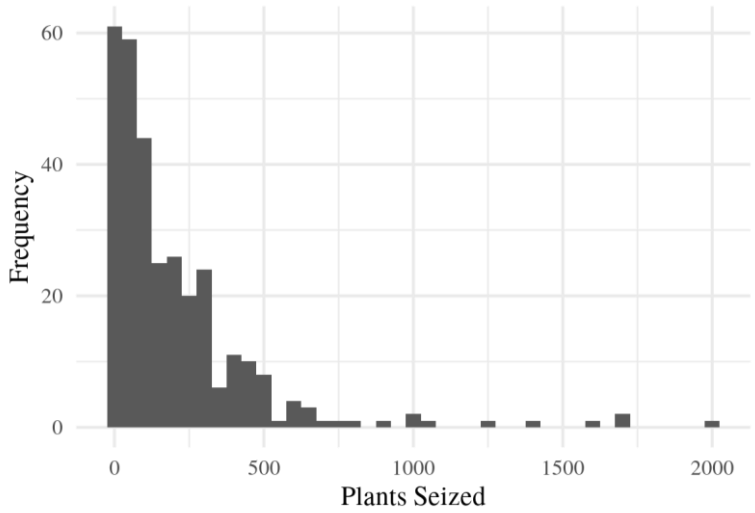

Figure 1 - Distribution of plants seized

Now we have the seizure in plants from each positively identified thermal operation, we can build the final monetary benefit for this type of operation, by multiplying the number of plants by the value of each plant.

In order to take uncertainty into account, random selections were taken from the above distribution (5 times) for each of the 318 operations and then averaged the results to obtain the total number of plants seized. The total number of cannabis plants seized was 70,220 across 318 operations, yielding an estimated value of £70,220,000. This value is then multiplied by the impact factor to give us the monetary benefit value for drone operations with regard to identifying cannabis farms.

Therefore, the overall monetary benefit of thermal operations is:

$$\underline{Total\ Thermal\ task\ benefit = £70{,}220{,}000 * 0.2 = £14{,}044{,}000}$$

3.1.4 Crime Scene Footage

Recently, the drone unit has been used to survey and capture footage of crime scenes and murder scenes. The use of the drone is two-fold, it can be used to help crime scene investigations by allowing a greater evidential opportunity through time saving and resourcing, and the drone can also be used to capture footage from murder scenes to show point of view imaging to assist when presenting evidence at trial.

Firstly, looking at the evidential opportunity, the use of a drone is beneficial in the way that it allows better resourcing for looking and gathering evidence. Not only that, it allows for alternative methods of evidence collection which would not normally be completed by officers, such as searching roof tops and guttering. These are activities which show an obvious benefit, however, for the purpose of this study are difficult to assign a monetary value.

In recent years during murder trials, the number of times a court will visit a murder scene has declined, and with the covid pandemic, stopped completely. This is due to a number of reasons, which mainly revolve around the cost and the availability of alternative methods. The use of a drone to capture footage and convey a timeline to be used at trial has become an increasingly beneficial method. The drone not only provides aerial imagery of a scene, but can also provide eye-level, point of view footage to show the route a suspect may have taken.

While the court visits to a murder scene were already in decline, subject matter experts expressed that since the use of the drone, they don't envisage a need for court visits in the future. Furthermore, they suggest that the footage captured from the drone is to a standard where it is more beneficial than a court visit ever was, given the different views it is able to produce. Therefore, it is possible to deduce that the crime scene videos captured by the drone would have a beneficial saving equal to the cost of a crime scene visit from a court. The conservative estimated costs for a court visit to a murder scene are as follows[6]:

Cost Item	Quantity	Cost per unit per day	Total Cost per visit
Court costs	1	£2,692	£2,692
Barrister	4	£1,200	£4,800
Junior Barrister	4	£600	£2,400
Juror	12	£66	£792
Judge	1	£442	£442
Transport (coach)	2	£480	£960
PCs	5	£198	£990
Risk Assessment	1	£198	£198
Total			£13,274

[6] As provided by FCID and various online sources.

In the time period used in this study, there were 48 operations listed as *Crime Scene*. Having spoken to the drone operators, they estimate that 90% of these would have been to collect footage for use in a murder trial, therefore, completing 43 operations. This was further confirmed by homicide officers, who also commented that the use of the drone is becoming more routine in their evidence and court preparations.

$$\underline{Total\ Crime\ Scene\ benefit = £13{,}274\ * 43 = £570{,}782}$$

3.2 Drone Unit Costs

This section will look into the costs associated with running the drone unit, both from the perspective of equipment required to perform their duties, as well as the staffing costs associated with running a double crew drone unit 24/7.

3.2.1 Equipment costs

For the year 2020-2021, the drone unit diligently collected and retained all the equipment costs incurred by the unit. These costs can be seen in Table 5, and are seen to total £36,667.46. These numbers are taken from the drone strategy report.

Table 5 - Equipment costs for Drone unit

Equipment	Quantity	Unit Cost	Total Cost
Deployment bags	2	£37.41	£74.82
Fire extinguisher	2	£49.80	£99.60
Cones	2	£29.99	£59.98
Helipad	2	£12.04	£24.08
Anemometer	2	£14.99	£29.98
Work light	2	£13.74	£27.48
Binoculars	2	£74.16	£148.32
Tape	1	£6.66	£6.66
First aid Kit	2	£11.87	£23.74
Torch	2	£147.65	£295.30
GCV	14	£500.00	£7,000.00
GCV(x1) + NQE/GVC Conversion (x6)	7		£2,294.00
NQE-GVC Conversion	15	£99.00	£1,485.00
Mavic Mini	1	£556.67	£556.67
Servicing	1	£790.00	£790.00
Gimble damper	1	£30.00	£30.00
Label machine	1	£144.87	£144.87
Nuts/Bolts	1	£19.95	£19.95
Table cover	2	£17.65	£35.29
Folding table	1	£45.83	£45.83
Matrice M300/Battery/Controller	1	£17,900.00	£17,900.00
HDMI Spliters	2	£15.00	£29.99
USB cables 3pack	3	£14.16	£42.49
USB charging station	1	£80.00	£80.00
Tool sets	2	£15.00	£29.99
Camping chairs	1	£22.50	£22.50
Binoculars	1	£117.95	£117.95
128gb Micro SD card	4	£23.66	£94.64
Matrice M300 dual gimble connector	1	£158.33	£158.33
Matrice M300 2110 propeller (pair)	2	?	?
Counter Drone effector course	11	£454.55	£5,000.00
Total			£36,667.46

3.2.2 Staffing costs

Currently, the staffing for drone operations is built up of the core drone team who oversee all of the staff and pilot training for drone operations, as well as the admin and maintenance of aircraft. They will also perform some of the pre-planned flights. This core drone team is made up of 7 PCs and 1 Sergeant.

In addition to this, there is a pool of circa 40 officers who are trained pilots. These officers mainly belong to Force Support Unit (FSU), however, some belong to Neighbourhood Policing Units (NPU). FSU has a commitment to provide a doubled crewed drone unit on every shift, therefore 6 officers across 3 shifts, and 365 days a year. This will allow us to calculate the cost of the staffing of the drone unit in isolation from the wider FSU (even though these officer costs currently belong to FSU).

For the FSU drone officer cost, it would require 6 officers on duty per day, with 2 further officers on rest days, meaning a total of 8 officers. Using numbers provided to us from Workforce Planning, the average attendance is 70%, with non-attendance attributed to 20% annual leave, 5% sickness, and 5% for other reasons (vacancies etc.). Therefore, to calculate the total team size required, which give the minimum number of officers required on-duty per day, by a factor of 1.43 = $(\frac{100\%\ officers\ required\ per\ shift}{70\%\ average\ attendance})$. This results in a required team size of 11.44 ~ 11 officers.

The overall costs associated with police officers, when factoring all variables such as annual leave and pensions, is £51,700 for PCs and £63,300 for Sergeants.

With this information, we can calculate the overall staffing costs of running the drone unit in its current composition and with its current ways of working:

$$Total\ Staffing\ cost = 7\ Drone\ Unit\ PCs + 1\ Drone\ Unit\ Sgt. + 11\ \ FSU\ PCs$$

$$Total\ Staffing\ cost = (£51{,}700 * 18) + £63{,}300 = £993{,}900$$

Total overall cost $= £\mathbf{1,030,570}$ per year

4 National Police Air Service (NPAS)

4.1 NPAS Operations

The National Police Air Service operates helicopters for police forces across the country, to which WMP is subscribed. The use of helicopters in policing has been prevalent for several decades, and has always been associated with the significant costs of running and maintaining an aircraft.

This section of the study looks to understand the types of operations performed by NPAS in the WMP region, and to compare these operations with those from the drone unit. The data provided for NPAS is for a time frame from 02/04/2020 to 28/01/2022. All of the logs in the spreadsheet provided have a matching CW log number, which has been used to understand the types of crimes and operations which NPAS has supported on.

The associated operation type for NPAS can be seen in Table 6. The total number of operations completed by NPAS totaled 808, however, the data presented in Table 6 doesn't show crime classes for less than 10 events.

Table 6 - NPAS Crime Class per operation

Crime class from CW	Count	Proportion
TRANSPORT - Road Related Offence	200	0.2475
WMP Police generated Activity	82	0.1015
PSW - Suspicious Activity/Premises/Vehicle	75	0.0928
Admin - Police generated Resolution	54	0.0668
Task - Arrest	44	0.0545
PSW - Concern for Safety	40	0.0495
CRIME - Firearms/Weapons	32	0.0396
PSW - Missing Person	25	0.0309
CRIME - Burglary (Residential)	24	0.0297
CRIME - Assault	22	0.0272
Admin - Intelligence	20	0.0248
P9 - Vehicle Observations	20	0.0248
CRIME - Robbery	18	0.0223
Duplicate	18	0.0223
CRIME - Drugs	13	0.0161
Admin - Advice Given	12	0.0149
CRIME - Theft of Motor Vehicle	12	0.0149
TRANSPORT - Highway Disruption	10	0.0124

To understand the type of operations which can be directly compared between NPAS and the drone unit, we need to understand the crime types. There are only two primary operations that NPAS can do which the drone unit cannot; these operations are follow/surveillance on a vehicle pursuit and a search of a large expansive area. The reason the drone cannot do these tasks is due to current legislation around what a drone can or cannot do. The main limitation is that the drone currently cannot be flown beyond the line of sight of the operator, therefore for a vehicle pursuit it is not possible for a drone to follow.

Knowing this, it is important to discern from Table 6 which operations involved a vehicle pursuit. The operation listed *TRANSPORT – Road Related Offence*, which accounts for nearly 25% of all NPAS flights, is the primary source for vehicle pursuits, however there are other crime types which include pursuits, namely *CRIME – Theft of Motor Vehicle* and *TRANSPORT – Highway Disruption*. Combined, these accounted for 222 NPAS flights.

In addition to these crime types, it was important to consider whether any of the remaining 586 crime types include a vehicle pursuit. Following a survey of 146 CW logs from the remaining 586 crime types, 60% of the remaining logs included a vehicle pursuit. Therefore, by using this proportion across all the remaining cases we have an additional 357 crimes which involved a vehicle pursuit. This finally leaves 229 cases which did not involve a vehicle pursuit.

It could therefore be inferred that, if there were sufficient drone resources close enough to such incidents, that drone could be able to satisfy the support request instead of NPAS.

4.2 NPAS Costs vs Drone Costs

To calculate the potential benefit from alleviating relevant NPAS operations and replacing them with drones, the associated costs need to be understood.

WMP allocates a budget of £1,663,500 per year for their use of NPAS, which equates to £4,475.34 per day. The period of NPAS records we have access to from 02/04/2020 to 28/01/2022 which equates to 666 days. These two numbers multiplied together give a total cost over the period of £2,980,578.

During this period, NPAS completed 808 operations, so when the total period cost is divided by the number of operations, we get the average cost per operation, which is £3,689. This cost per operation can be directly compared to the cost per operation of drone unit for the relevant operation types which could by undertaken by the drone.

There were 2,480 operations performed by the drones over 761 days, creating an average of 3.25 operations per day, and a cost per operation of £866.Therefore, for the operations completed by NPAS, which could have been undertaken by a drone, had there been sufficient drone resource, would equate to:

$$\underline{Drone\ Operational\ Saving = (£3689 - £866) * 357 = £645{,}720}$$

With the data provided, it is not possible to calculate the monetary benefit provided by NPAS since details are limited and the outcome of each operation is not known. Therefore, it is also not possible to provide a comparison between the benefits provided by NPAS vs the benefit provided by the drone.

5 Discussion

During the course of this study, it has been apparent that there are some activities where it is very difficult to quantify the benefit provided by the drone, even though the benefit is clear and logical. The majority of these activities cover operations where the drone is very much a *bonus* resource. This section will look at several examples, and provide commentary from discussions with SMEs as to how the drone is a valuable resource to their operations.

5.1 Events, Protests and Football

The drone has become a routine resource used at large scale public events and protests. In addition, the drone is also regularly used at high risk football matches, such as local derbies. The objective of the drone at events like these are to provide greater surveillance to the police officers on the ground. The mobility and non-intrusive nature of a drone means that is able to provide a live feed of footage and information on a range of topics.

Most notably, the drone is used to track crowd movements and use these visuals to predict where crowds might be going. In the example of a high risk football match, the drone would be able to see whether or not two groups of rival fans are about to clash where there is no police presence. This allows the Gold, Silver, and Bronze commanders to make policing decisions to move officers to prevent hotspots of violence.

The same approach is taken at large public events such as protests and music festivals. An example would be a flare up of violence in a music festival, before the use of the drone, a call would be broadcast to officers on the ground, without any precise details of the size of the disorder or exactly where it was occurring. With the use of the drone, officers are able to provide more efficient resource during periods of disorder, allowing other officers to be on stand by for any further events. Another such example was at Godiva festival in Coventry, where the drone was able to identify groups of teenage males who were encircling festival goers who were alone and demanding that they hand over their belongings. The footage provided by the drone led to the arrest of these offenders.

It was noted that the presence of a drone at large events does not change the number of officers resourced on the ground. However, after an event has begun, there have been instances where the drone has been able to show footage of the size of the event, and this has meant that resourcing has been reduced or increased dependent on the crowds observed. This is due to the drone assisting in providing the overview of an event to assist commanders in the dynamic decision making about the appropriate level of police response.

5.2 Assisting Arrest and Warrants

Another operation where the drone is becoming a routine resource in policing is during the execution of search and arrest warrants. The job of the drone officers usually begins before the warrant execution, where they will fly the drone around a property to perform a recce (reconnaissance). The objective of this is to ensure that the appropriate risks are known before the warrant takes place.

During the warrant, the drone acts as a bonus resource and will usually fly over the rear of a property to see if anyone attempts an escape to the rear. This means that officers

would have better visibility of a situation, but also a greater chance of apprehending a suspect that may attempt an escape.

Furthermore, there are several examples where a drone has observed suspects attempting to dispose of evidence through a rear window of a property. In one example, the drone observed a suspect lean out their window and throw a package onto a neighbouring roof. The package was found to contain Class A drugs, and without the use of the drone, the property search would have likely found no evidence.

5.3 Evidential Opportunity

The previous example leads onto a discussion on the use of a drone and how their use increases evidential opportunities. In the case of a homicide, the use of a drone can not only drastically reduce policing time and costs for searches, it also increase the types of searches that are available to an investigating officer.

One such case is when a drone was used to search the guttering of a property for any evidence that might have been disposed of. In this example, the drone was able to spot a knife, which turned out to be the murder weapon, in the guttering. Had the drone been unavailable a few things might have happened. Firstly, it might have been decided that it wasn't worth the investment in time and resource to check the guttering, or secondly, it would have required detailed risk assessments, specially trained personnel and specialist vehicles to look for the weapon. With the drone, the identification of the weapon would have taken less than 20 minutes, leading to significant saving in time and resource.

Another example stems from the drone usage at large public events. As a live feed, the drone is very useful to officers on the ground, on the day; however, the footage continues to be valuable after the event. In this scenario, the drone is used for surveillance purposes, however, that surveillance can also be used in evidence. Should large scale disorder break out, the drone footage, coupled with CCTV, can be used to piece together evidence, track offenders, identify them, and lead to a prosecution.

While the drone alone would not necessarily provide the evidence to lead to a prosecution (it can if it witnesses something), it can be used with other sources of evidence to verify the movements and identity of individuals (not via facial recognition but officers' investigations). Such evidence is subject to all the normal evidence retention procedures, particularly if footage is not required for subsequent investigations.

5.4 Current Drone Legislation, and Potential Future benefits

Finally, one of the limiting factors of drone usage in policing in England and Wales is the legislation surrounding drone usage in general. The legislation states that the operator(s) of a drone are not permitted to fly a drone beyond the visual line of sight. This, therefore, dramatically limits the type of operation the drone can do without needing to land and move on to another point to take off from.

This is the reason NPAS still has significant value to WMP. As we detailed in Section 4, more than 71% of NPAS operations in WMP involve some form of vehicle pursuit. For the time being, NPAS remains the best additional resource to assist on operations such as this. However, should the legislation surrounding flights beyond the visual line of sight be amended, then it is feasible that drones would be able to provide similar support in

situations such as this. Note, this would be a force level decision that would require significant further work, and is not a recommendation from this study.

Furthermore, with the knowledge that the drone could have provided the appropriate support required to 357 NPAS operations, coupled with the 879 instances where the drone was requested but not available, there are a total of 1,236 operations where the drone did not attend but could have potentially attended.

When compared to the number of operations where the drone registered a flight time of greater than one minute (2,480), the number of operations attended by the drone could be increased by nearly 50% in a two year period. This statistic, when compared with the overall benefit / cost figures in Section 6, could be used to justify further investment in the drone team.

6 Benefit - Cost Results

From the analysis in Sections 3.1 and 4.2, we are now able to build an overall benefits picture for the drone unit. The breakdown of the benefits can be seen in Table 7.

Table 7 - Overall Benefits for Drone Operations

Task	Type	Value
Search for Misper	Benefit	£156,860
Search for Offender	Benefit	£357,421
Thermal Task	Benefit	£14,044,000
Crime Scene	Benefit	£570,782
NPAS operations	Potential Saving	£645,720
Total		£ 15,774,783

The total benefits in this study are calculated over the time period Jan 2020 to Jan 2022. Costs are calculated on a yearly basis, therefore it is important to normalise all values to allow for accurate comparison.

Between the dates 01/01/2020 and 31/01/2022 are 761 days. Therefore, the average benefit contributed by the drone unit per day equates to £20,729. We know the total cost for the drone unit per year is £1,030,570, therefore the total cost per day is £2,823. By comparing these two numbers together, we can get a benefit / cost ratio of 7.34.

Furthermore, the number of flight hours in this period was 881, meaning 1.16 hours per day. This calculates to be a cost of £2,439 per flight hour, and a benefit of £17,906 per flight hour.

The benefit / cost analysis can be extended to a per operation benefit. Of all the operations performed by the drone team, whether or not we have calculated a benefit value, there were 2,480 operations performed over 761 days, creating an average of 3.25 operations per day, and a cost per operation of £866. The benefits per operation translate to £6,361.

Table 8 - Tabulated results

	Cost	Benefit (ratio)
Per day	£2,823	£20,729 (7.34)
Per Operation	£886	£6,350 (7.17)
Per flight hour	£2,439	£17,905 (7.34)

Appendix A

Data collection and cleaning

Looking at the Centrix database, it contains columns detailing the date of the flight, time of the flight, flight time, and post code/location. It also contains details of the pilot responsible for the drone, as well as their department. Importantly, this database also lists whether each operation was planned or spontaneous, as well as the operational category. Most of the categories in operational details match up to the details contained in the Detailed spreadsheet. Most importantly, this database lists the outcome of an operation; whether the operation had a positive or negative outcome. This field is imperative for understanding the monetary benefit the drone unit has contributed. The Centrix database had a total of 2,718 flights from unique locations listed (some incidents had more than one flight, if there were more than one flight at the same postcode on the same day, they were considered to be the same incident).

The Detailed spreadsheet contains similar information as Centrix, namely information on the date of the flight, flight time, location, and pilots involved. However, the Detailed spreadsheet contains better information and details regarding the types of operations conducted by the drone unit. Namely, it contains fields search for offender, search for misper, assist arrest, thermal task, crime scene, football, event/protests, warrant assist. The Detailed spreadsheet also contains a notes field which is utilised to give context to each operation. However, this spreadsheet offers no indication of the outcome of the operation. The Detailed spreadsheet also contained a log number, which when combined with the date will result in a Unique Reference Number (URN) which is the unique number used for incidents in Control Works (CW). The Detailed spreadsheet contained 2,485 incidents when the flight time was greater or equal to 1 minute (anything less than this was considered not relevant to this study) and where the log number was in a format where a URN could be inferred.

Matching process

The matching process was as follows:

1. Query was used to extract all the URNs, dates, and postcodes from CW between 01/01/2020 and 31/01/2022 where a drone resource was associated with the incident.

2. The postcodes were then translated into neighbourhood codes.

3. Iteratively, each row from the Centrix database was then compared to the CW data.

4. Where the date and neighbourhood from Centrix matched with the date and neighbourhood from CW, the resulting URN record would be associated with the Centrix data.

5. The matched URNs contained in the Centrix data were then compared to the URNs contained in the Details spreadsheet. When there was a match, the associated records on the two databases were linked.

This process allowed for the linking between the previously unlinked data. However, throughout this process, it did result in some significant data loss where records were not able to be accurately matched. A method to use the records where no match was present is detailed in Section 2.4.

Bayesian Linear Modelling for Thermal Tasks

It is not possible to know exactly which cannabis seizures can be linked to the drone activity, however, it is possible to measure the overall impact of the use of the drone on the number of cannabis seizures. To do this, we took all the cannabis seizure data from 2010 to 2021, and from 2019 onwards, a dummy variable was introduced to indicate the drones were in use in the force (but not necessarily on every cannabis seizure). Along with the drone variable, we introduced the overall crime numbers as a variable too, to give context to wider issues at any given point in time. These variables were then used in a Bayesian Linear Model to estimate the coefficients (size of the effect) of model variables. The model was able to weakly suggest that drone usage in WMP has an impact of 0.2 on the seizure of cannabis.