

# Experience, Adjustment, and Engagement: The Role of Video in Law Enforcement

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## ABSTRACT

Questions about the effectiveness of increasingly ubiquitous video technology in law enforcement have prompted an examination of the practices surrounding this technology. We present the results of a multi-site study aimed at understanding the use of video in several phases of law enforcement, from crime prevention and response to investigation and prosecution. Our findings show that while video has provided numerous benefits to law enforcement agencies, in many cases the technology either fails to support key facets of work or introduces new tasks that present an additional burden to workers. We discuss the need to incorporate human experience and tacit knowledge, operator engagement, and the greater ecosystem of work into video deployments.

## Author Keywords

Law enforcement, contextual inquiry, qualitative studies, video technologies, ubiquitous computing, surveillance.

## ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## General Terms

Design, Human Factors

## INTRODUCTION

Law enforcement agencies invest heavily in technologies that promise to decrease response times, protect officers in the field, improve situation awareness, and increase both the quantity and quality of evidence collected at the scene. These technologies include GIS/GPS, video analytics, and digital archiving of evidence. In particular, a growing number of municipalities are incorporating closed-circuit television (CCTV) and other forms of video surveillance and recording [6][10][17].

Debate is ongoing regarding the value and effectiveness of video technology in law enforcement, in terms of how its adoption affects crime rates and its impact on privacy and

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Figure 1: CCTV control room, site UK3

public perceptions of safety. Despite these uncertainties, recording and surveillance have become increasingly ubiquitous in law enforcement over the past few decades, and municipalities are rapidly adopting the technologies. There is, however, concern that more is being invested in the deployment of additional technology than in understanding how to integrate existing technology effectively into jobs and work processes. Recently, an internal report from the London Metropolitan Police stated that roughly £200 million have been spent on over one million CCTV cameras in London between 1996 and 2006 [5]. Detective Chief Inspector Mick Neville of the Metropolitan Police provided the following observation:

*“What I would say...is we've got enough cameras, let's stop now, we don't want any more cameras. Let's invest that money that's available and use it for the training of people, and the processes to make sure whatever we've captured is effectively used” [5].*

Although numerous studies have investigated the correlation between the use of video technology and crime rates [13] [22] [26] and public attitudes towards video surveillance [24] [10], less is known about the role of these technologies in the tasks of law enforcement personnel, and how it shapes their responsibilities and work experiences. This research aims to understand the end-to-end use of ubiquitous video in law enforcement, spanning multiple law

enforcement roles, work contexts, and types of facilities throughout the life cycle of the video data. We have conducted a multi-site qualitative field study spanning incident response, command and control, investigation, and prosecution. Our field inquiry into seven different law enforcement sites, security offices, and CCTV control rooms throughout the United States and Great Britain revealed the evolving role of video technologies in personnel work activities, as well the often unexpected ways in which these technologies both support and hinder law enforcement tasks. Our findings indicate that in many cases the technology was able to deliver on its promise of improving the ability of law enforcement personnel to do their jobs. However, the analysis also revealed ways in which technology was neglected, created additional and sometimes unnecessary burdens on workers, or had unexpected effects on certain aspects of work such as job satisfaction. Our investigation also revealed the importance of tacit knowledge and experience in video monitoring and surveillance, and the inadequacy of technologies designed to accomplish these same tasks. In this paper, we report on our findings, noting broader tensions between technology and law enforcement work that appeared in some instances across roles and work cultures.

#### BACKGROUND AND RELATED WORK

The development of video technology for law enforcement originated in the mid-to-late 1960s, beginning with in-car police cameras [1] and the first public-space CCTV surveillance systems [2], although CCTV was used for isolated events prior to that time. The use of video expanded rapidly in the late 1990's and early 2000's, with over 70% of US vehicles now equipped with on-board cameras and anywhere between 3-5 million CCTV cameras deployed throughout the UK [14]. In addition, major American cities such as New York, Los Angeles, Chicago, Philadelphia, and Washington D.C. all have some form of CCTV surveillance in effect.

In recent years, authorities in many of these metropolitan areas have commissioned or assisted research efforts on the effectiveness of these deployments, focusing on reductions in crime and post-incident crime-solving. [7] [13] [22]. In some cases, news journalists have also acted as watchdogs for the effectiveness of video surveillance [6] [17]. These studies report a variety of results, with some claiming substantial reductions in crime while others showing that crime rates were essentially unaffected. For example, one report estimates that in 2008, only 1000 prosecutions in London were assisted by CCTV, roughly one prosecution for every 1000 cameras deployed. [5] Some investigators observed a displacement effect, whereby crime was essentially pushed beyond the range of CCTV [26]. Reports cite the importance of control-room operations as equally important, or in some cases more important, to video for crime prevention: "The skills, knowledge and motivation levels of the operators determined how well they identified

live incidents and whether they succeeded in obtaining evidential-quality images." [12]

The most extensive studies to date on the use of video in law enforcement are those of Gill *et al.* commissioned by the UK Home Office [12] [13], and those of Keval *et al.* [15] [16]. Keval and Sasse report on a series of observations and interviews at 13 CCTV control rooms in the UK. Their study focused on the technologies used in the day-to-day operation of these rooms, including cameras, communication tools, monitors, and controls. Their results list a number of areas where technical issues interfered with the effective conduct of work, including camera placement, video quality, and ergonomic factors in the work environment. The study also notes the importance of intuition in proactive monitoring, a factor that we later examine in more detail in terms of its relationship with automated monitoring systems.

Gill *et al.* performed an extensive study including over 500 hours of observation in 13 different CCTV control rooms. These observations included a number of suggestions regarding proper management of control rooms, control room design, and communicating with external agencies. Importantly, the study found that additional responsibilities such as evidence management compromised the ability of video operators to conduct their primary monitoring tasks. In addition, the study mentions in passing the importance of experience and geographic knowledge to operator effectiveness. Our study follows up this earlier work by examining CCTV control rooms that have since implemented some of their recommendations, such as digital video, police radios, and resident police officers.

In addition to the aforementioned studies, other research in the literature utilizes police observations but does not specifically focus on video. Nulden [20] cites a number of tensions such as autonomy, proactivity, and control in police patrol work. Colton [9] examines the reasons for adopting or neglecting several police technologies such as computer-aided dispatch (CAD) and computer-based resourcing. The COPLINK system [8] uses police observations to inform the design of a search interface for accessing police crime databases.

Other studies look at response processes for other agencies such as fire departments [18] and emergency dispatch [19]. These studies nevertheless highlight the importance of work rhythms and communication patterns that lie outside the domain of available technology, making recommendations for how the technology can better support them.

Our study complements past research on video in law enforcement with additional observations regarding the context in which these technologies are employed. In particular, our research looks at the role of video in an end-to-end fashion across a variety of work contexts. Our inquiry examines how workers in roles ranging from CCTV operators to prosecutors used video and how it shaped their jobs. We considered the life cycle of video including its

capture, indexing and storage, retrieval, and use. From this perspective, we are able to outline not only the technical shortcomings of some of these technologies, but higher-level observations about how well technologies complement particular roles across a variety of environments within the law enforcement process.

**METHOD**

Video technology plays a role in many phases and areas of law enforcement, from incident response and arrest to investigation and prosecution. In many cases, the same video data is passed through all of these phases, necessitating procedures for its recording, storage, and access. In addition, these procedures must maintain a chain of evidence that ensures the media is not altered from its original state. In order to determine how video technology supports each of these phases, we conducted a multi-site field study focusing on the role of video in the law enforcement process.

Our selection of study sites was constrained by the difficulty of gaining access to law enforcement facilities, but represents a broad range of facility types nonetheless. Ultimately, we were able to gain access to seven separate sites in the US and UK, including four CCTV control rooms in two major cities in the UK, a combined CCTV and police station, a district attorney’s office in the US, and a police facility in the US that used mobile video in squad cars. These sites are summarized in Table 1.

Participants were recruited from many different roles, including eleven CCTV video operators, five full-time police officers, one records clerk, two property and evidence technicians, and four prosecuting attorneys. We performed a contextual inquiry [3] employing several qualitative methods for data collection, including semi-



**Figure 2: A portion of the affinity diagram used in our analysis**

structured interviews, observation and shadowing, and artifact collection. The amount of time spent and the number of researchers visiting each site varied depending on the complexity of and access to the facility. The number of hours spent at each site ranged from approximately two to sixteen, with between one and three researchers collecting data. Our inquiry focused on the basic tasks and technologies used for each role, the role of the job within the greater context of the law enforcement process, communication within the site and between other agencies, and the use of video throughout. We employed multiple means of data collection, using audio recording and still photography when possible, and field notes when other recording was not permitted. Data protection policies varied between sites, with certain elements such as evidence in ongoing investigations and police radio communications not subject to recording for legal reasons.

Site code	Site description	Participants
UK1	CCTV control room, city center of a major city in northwest England	Two video operators, a resident police officer, and a CCTV manager
UK2	CCTV control room, northern suburb of a major city in southeast England	CCTV manager and two video operators
UK3	CCTV control room, eastern district of a major city in southeast England	CCTV manager and part-time police officer, a team leader and video operator, and two video operators
UK4	CCTV control room for a small public space and a shopping center in the city center in southeast England	Two video operators
UK5	Combined CCTV and police facility for a town in southern England	CCTV manager, emergency call-taker, police dispatcher, two video operators
US1	Police precinct and district attorney’s office for a medium-sized town in the southwestern US	Three police officers, a property and evidence clerk, and two prosecutors
US2	District Attorney’s office of a major city in the eastern US	Three assistant district attorneys (ADA’s), an IT manager, and a detective in special narcotics, two ADA’s in the trial bureau

**Table 1: Sites observed and participants interviewed for the study.**





(a)



(b)

Figure 3: Work environments for US1 (a) and UK5 (b)

We used a grounded theory approach as our primary method of data analysis. We extracted roughly 1800 items from interviews and field notes, most of which consisted of direct quotes. The remainder of the items were observations and paraphrased comments taken from interviews that were not audio-recorded. We subsequently performed a team-based affinity analysis in which key themes and findings were derived by performing an iterative, bottom-up categorization of the items [3] (Figure 2).

### FINDINGS

In performing our data analysis, three key themes emerged concerning how the emergence of video technology affected the roles of workers in law enforcement processes. Specifically, these themes concern the interplay between human capabilities and video analytics *during* the capture and transmission of video; the additional tasks and responsibilities such as tagging and storing that arise to make captured video useful *after* it is recorded; and the unexpected role that video plays in worker engagement and job satisfaction not only when workers are actively interacting with video, but when it has moved *beyond* the realm of their job responsibilities. In the following sections, we present an overview of the various sites and roles we studied, and then delve into these key themes in detail.

#### Overview of the work context

All of the CCTV facilities observed are responsible for monitoring and responding to video feeds from cameras in public spaces. The sites included in this study monitor anywhere from a few dozen to several hundred cameras. Video feeds from CCTV cameras are recorded continuously, either onto VHS tapes for analog systems or onto servers for digital systems. For our study, all sites were using digital video systems with the exception of UK4, which has a hybrid digital/analog system. Recorded video is stored for a period of time after which it is deleted if it is not determined to be associated with an incident. This

retention period varies from site to site, but is between 28 and 31 days.

CCTV operators are responsible for the control room's primary tasks of monitoring live video and communicating with other agencies to prevent or respond to crime. A typical operator's workstation includes a shared video wall, a local "spot monitor" for detailed viewing, a GIS monitor for location lookups, controls for manipulating and switching between cameras, and a variety of communications equipment for contacting police, other control rooms, and local businesses (Figures 1 and 3b). Operators typically work in 8- or 12-hour shifts scanning available camera feeds or responding to ongoing incidents by directing cameras to areas of interest. Control room managers are responsible for communicating with external agencies such as city councils and police, implementing initiatives and arrest targets that these agencies may impose, and ensuring that operators abide by a code of practice [25] in their work. Some CCTV locations also have resident police officers who serve as liaisons to the local authorities. These officers are largely responsible for reviewing footage for evidence, but may also serve as video operators. Additional details on the tasks and goals of CCTV workers are outlined in previously mentioned studies of CCTV control rooms [12] [15].

The US1 police precinct makes extensive use of digital video obtained through cameras installed on the front of patrol cars (Figure 3a). Patrol officers are assigned to a particular geographic area, or "beat". They are responsible for maintaining safety in this area by patrolling and responding to incidents and emergencies. Video recording is triggered automatically when an officer turns on the vehicle's emergency lights; the police officer can also start the recording manually. Officers upload recorded video to servers in the police station, after which it is maintained by a clerk in the precinct's property and evidence office. This

clerk catalogues evidence submitted by officers and later retrieves it when requested by either officers or prosecutors.

Site US2 was observed to make use of a variety of recorded media. Video is obtained from several sources, including hidden (body-worn) cameras, in-car cameras, surveillance footage, and security footage from external parties such as private businesses and transit authorities. In addition, personnel also use recorded audio from such sources as wiretaps and microphones worn by undercover officers or informants. Prosecutors, detectives, and assistant district attorneys (ADAs) can request media associated with particular incidents from a “wire room” that catalogues media obtained from investigations. They review video and identify key sections that will serve as evidence in court alongside other forms of digital and conventional media.

In addition to the primary roles described here, our study also included interviews and observations with IT managers, police dispatchers, and emergency call-takers.

### The irreplaceable human in the loop

The rapid adoption of video surveillance has given rise to an increased need for tools to assist in monitoring the amount of footage produced by tens or even hundreds of cameras. Audio and video analytics are generally seen as a promising technology for providing this assistance by many of our participants. In CCTV control rooms where the camera-to-operator ratio can in some cases be fifty to one, this technology is seen as a means of monitoring areas that otherwise would not be visible to operators.

Sophistication of commercial offerings in this area can vary; some systems offer relatively simple functionality such as the ability to track rapid motion in a video frame or identify license plate numbers. Other systems are intended for detecting more complex events and behaviors such as fights, crowd formation/dispersal, loitering, or gunshots.

All five of the CCTV sites we studied currently used some form of video analytics, but these systems were limited to less-sophisticated technologies such as motion-tracking cameras or automatic number plate recognition (ANPR). One US site, US1, had a simple mechanism on patrol cars to automatically zoom in on license plates during traffic stops. In addition, one officer, US1-3, wanted an in-car camera that could track him once he had left his vehicle as an additional safety precaution. Several sites had tried more sophisticated systems in the past but had abandoned them because of poor performance, with the exception of site UK3, which reported some success with the use of audio analytics to detect gunshots.

In examining the reasons behind this lack of adoption, our findings illustrate the importance of human experience and intuition in interpreting the content of video effectively.

#### *Human tacit knowledge is critical*

In describing how they proactively detect incidents in live video, some CCTV operators at first found it difficult to articulate exactly what they would look for, or what would

attract their attention. UK2-2 states “You’re not really thinking of it, it’s just something catches your eye.” Overall, the cues that the operators found were complex, subtle, and intangible, described by UK1-5 as, “hunches, body language, experience, familiarity.” Similarly, UK1-2 said, “80% of this job is experience.”

Many of the operators mentioned the importance of the body language of people being observed in video, but still had difficulty conveying this knowledge more specifically. UK5-5 commented that reading body language was, “very hard to describe... it’s just there. I don’t even think about it now.” The operators considered body language to be something inherently human that could be learned over time but not really taught, as reflected in their training:

*“[We] trained some in basics, but most of it is from experience. Faces, body language—it takes years.” [UK1-2]*

*“They did go over it a bit [in training], but not a terrible amount. It’s just human nature.” [UK2-2]*

This tacit knowledge [21] gained through years of experience was crucial to their effectiveness on the job, as evidenced by several incidents that were described. In one instance, UK5-5 described the arrest that occurred after she saw an elderly man walking with a young girl. Although she did not recognize either person, she correctly ascertained that the man was a sex offender. She said she discounted the possibility that the man was the girl’s grandfather because, “her body was rigid, she didn’t look comfortable.” Other comments from operators also indicated the importance of this skill and how much they could infer from it:

*“At night, you get to reading people’s body language. Two people look as if they’re talking, but you can tell by the body language they’re not. And you think to yourself, something’s going to kick off there, and then suddenly one will whack the other one.” [UK2-2]*

In addition to body language, operators reported other intuitions, tacit knowledge, and experience that made them particularly adept at detecting impending trouble. For example, UK1-3 claimed “I can see a robbery ten minutes before it happens.” These intuitions extended to sounds heard in communications with officers in the field:

*“The other week there was a call to a hostel, and the minute the police officer got there, you heard his voice, you knew it was bad, you could just hear it in his tone of voice.” [UK2-2]*

*“I had an incident a number of years ago where an officer was in a domestic, and it was one of those gut instinct things... there was just a noise over the radio... but on a gut feeling, I sent backup there, and it turned out that somebody was waving a knife at her.” [UK5-4].*

*“A couple of chips away”: Inadequacy of current analytics*  
In comparison, video analytics technologies fell far short in terms of ability to detect events of interest, and overall

proved to be “more of a hindrance than a help” [UK5-3]. UK5-1 noted “I was advised last year that they are a couple of chips away yet.” With the exception of ANPR, sites had largely abandoned the use of technologies for automatic incident detection. One site, UK3, had tried six different analytics systems before dismissing the technology. People who had used them expressed general dissatisfaction with their performance at noticing things that the operators noticed:

*“To detect what we specialize in, which is violent crime, it’s not sophisticated enough at the moment.” [UK5-1]*

*“What we were told was if [a crowd] was unusual for the place, it would say to you, ‘This is unusual’... And you could sit there... see this, and think, ‘Why isn’t it appearing there?’ And it didn’t come up and give you that alert, which is what it was supposed to do.” [UK5-3]*

Analytics software failed to embody the local knowledge and experience that operators had which allowed them to understand what was happening in the video:

*“There’s a notorious kebab shop in [a neighborhood]. Three o’clock in the morning, it’s busy, three o’clock in the afternoon, it’s not. [The software] needs... to be able to spot the unusual. Al of a sudden there’s three people outside the kebab shop at ten o’clock in the morning, that is unusual.” [UK5-1]*

*“Why are you [video analytics software] telling me this? There’s a man walking past with a shopping bag. It’s ten o’clock in the morning... What’s unusual about that? You tell me at three o’clock in the morning, I’ll take notice of that.” [UK5-3]*

Operators also mentioned more fundamental technical problems, such as audio detection that could not distinguish children playing loudly from a real incident [UK1-2], loitering detection features that identified trees, puddles, and reflections as loiterers [UK3-1], and time lags:

*“There would be a delay before [an alert] came up, and you need to see it now... It’s the difference between getting someone there in time to prevent something, or getting someone there after it’s all happened.” [UK5-3]*

Finally, operators’ poor experiences with analytics software even led to concern that it would reflect poorly on themselves and their ability to effectively handle incidents:

*“You’ve only got to miss it once. You get the inquiry, and the people come back and say CCTV [staff] weren’t doing their job. CCTV [staff] were, but the equipment failed.” [UK5-3]*

The CCTV operators’ comments regarding incident detection demonstrate the effectiveness that stems from complex and subtle knowledge and extensive experience possessed the operators. Current video analytics software that attempts to offload many of these tasks from the

operators simply cannot match human performance in complexity and reasoning.

#### **New tasks required with the adoption of digital video**

The introduction of digital video into some phases of law enforcement, rather than replacing, automating, or simplifying tasks, can instead introduce new tasks and responsibilities to those using it. While there are clear benefits of digital video, workers may often find themselves performing additional work to capture, search, and review it, tasks which frequently fall outside of what would be considered their core responsibilities.

#### *Recording video: More is better, but there are future costs*

In most of the sites visited, video was recorded either continuously (as in the case of CCTV) or in discrete time frames that could range from twenty minutes for a routine traffic stop to a few hours for a drug deal. The trend was to record more rather than less, as it is hard to predict when video will be needed or what will develop into an incident. UK1-1 stated “when in doubt, record it... if it’s nothing, it gets discarded.” A US police officer noted:

*“I don’t mind that is up and running at all times. It makes sense. If you think you saw something, you hit the record button.” [US1-2]*

Subsequently, this policy of recording more rather than less has resulted in high volumes of stored video, which can create future costs in terms of time and effort. For example, after the installation of digital video recorders (DVRs) in their squad cars, officers in US1 found themselves responsible for uploading video recorded during their shifts to the station’s servers using removable hard drives. For an 8-hour shift, the amount of video was often substantial, and took a significant amount of time to upload:

*“I don’t want to [upload video] during work time and possibly miss about an hour. So, I have to dock it at 10:00 PM and stick around until it finishes... I don’t want to leave it and pick it up the next day; I want to have it in my car at all times. What about if I see something on my way home?”*

#### *Facilitating search and retrieval*

In nearly all sites, high volumes of recorded video led personnel to create additional tasks and artifacts to facilitate future searches for locating particular videos and segments within those videos. In the case of our UK sites, CCTV operators made use of a number of sources, including police information, the memories of other operators, and their own internal logs. For example, operators in UK3 would locate an incident in their hand-written logs, then use that information to enter the date/time and cameras of interest into the software on their review console.

In the case of US1, officers were required to classify videos upon upload, tagging the video with metadata that indicated what type of content it contained. The intent of this policy was to give the property and evidence (P&E) office additional search criteria beyond date/time and arresting officer. The P&E clerk cited an instance in which a bank



robbery video took a long time to find because they did not know the responding officers and were confused about the date. Unfortunately, officers often neglected this policy, resulting in unclassified videos that essentially became “lost” and required a great deal more searching to locate. We observed several issues that contributed to this neglect.

First, officers used to collecting and submitting physical evidence did not view the procedure for submitting video in the same way. US1-1 summed up the problem:

*“Part of the reason there has been a disconnect for the police officers is...if they arrested someone and they’ve got a bag of marijuana, they put it in P&E and they fill out a form, whereas this is different, [officers] upload [video] themselves. [P&E] is not going to take the bag of marijuana unless the officer hands him a P&E sheet, but the machine is going to take the recorder and upload the video regardless.”*

In this case, the procedure for entering digital evidence is seemingly automated by the ability to upload the video. However, the same classification required for physical evidence still needs to be performed for video, but it has now become a diligence task for the officer rather than an enforced step of the procedure. Such a task can then be superseded by a variety of other higher-priority activities in a police officer’s day-to-day work.

Second, there was a dependence by both P&E clerks and prosecutors on notes that would indicate whether an incident had a corresponding video, and where in the video items of interest could be located. Without this information, videos would sometimes have to be reviewed in their entirety to find a particular event:

*“And then if there’s more than one officer on scene and it’s not clear from the paperwork who actually recorded it, just that video was recorded, then you have to watch ALL of them, all of the ones they recorded that day.” [US1-2]*

One prosecutor praised an officer for providing such notes:

*“Officer [name] is really good, even on the back of the citation, if she thinks it’s a civil case, she always writes, ‘audio/video available’ which isn’t the next step but is blatantly obvious so I know to request it.” [US1-2]*

The prosecutors themselves made use of hand-written annotations to keep track of important pieces of evidence:

*“[US1-1] I spent hours looking at that [video] ... and wrote myself notes so that when I got to court I would play it the right way.”*

US1 were not alone in their need for officers to be diligent about providing information to make recorded video useful. US2-1, a detective, related a cautionary story wherein a fellow officer had recorded several days of video in a surveillance operation. During the course of the operation, a car of interest drove through the frame of the camera. However, the officer forgot to mark the date and time at



**Figure 4: Binders of line sheets for a wiretap case at site US2. Note the post-its attached to items of interest within the binders, used for marking evidence that could be used at grand jury or trial.**

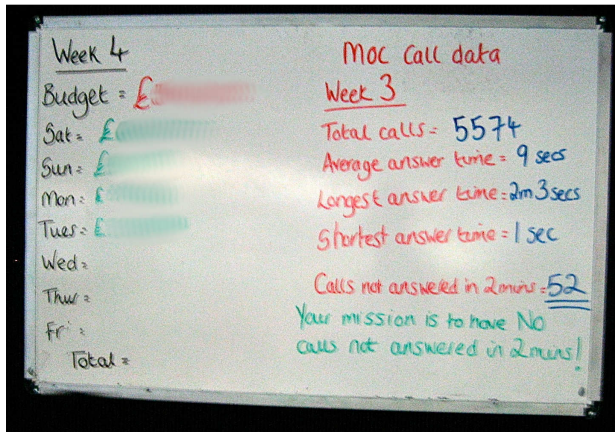
which the vehicle appeared. When, many months later, prosecutors needed this portion of the video as evidence, the officer had to review days of footage (in real-time) to locate the relevant portion, since by then the detective had little memory of those events.

Related to the video was the use of other digital media, which had similar impact on workers’ tasks. Narcotics cases involving wiretaps often involve weeks of recorded audio (a typical warrant lasts for 30 days). Summaries of recorded, or “pertinent” conversations called line sheets are distributed periodically to ADAs working on the case. These summaries can amount to reams of paper and require perusal by the ADA to identify those conversations which are most relevant to the case. US2-1, a narcotics ADA, showed researchers a spreadsheet he had created specifically to identify the line sheets he would use for a grand jury and potentially a future trial. In addition, post-its attached to the line sheets themselves served as bookmarks into pages of interest (Figure 4).

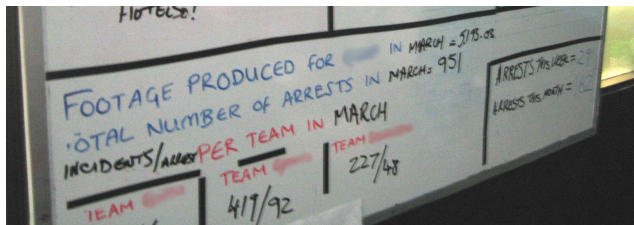
Given the largely paper-based nature of the state’s court system, records at US2 existed largely as printed documents and physical artifacts rather than digital documents or recordings. Case files themselves were physical folders containing all required documents and media (usually in CD-ROM or DVD form) pertaining to the case. Line sheets were also used in printed form, and ADAs did not have access to digitally sortable, searchable, or manipulable versions of this data.

#### **Increased engagement through video, little feedback**

Among CCTV operators, the use of video played a complex and interesting role in their sense of accomplishment and job satisfaction. Employees’ interaction with the video enabled them to see the events and incidents that they were addressing, thus fostering a deeper sense of personal engagement and effectiveness with the overall process. One operator described aspects of the surveillance experience,



(a)



(b)

**Figure 5: Whiteboard displays from CCTV control rooms displaying: (a) targets for response times at site UK1, and (b) team statistics for CCTV-assisted arrests at site UK2.**

“So the bun is the job, the icing is you’ve got the police officer there, the cherry on top is you get an arrest out of it.” [UK5-1]. Others described how seeing the video had an emotional impact on their experiences:

*“You do get the odd one or two jobs...where you really are in despair. Mine was a coach crash in Midhurst where three schoolchildren got killed.”* [UK5-4]

However, although the nature of the video technology drew the operators in and led them to feel a kind of social presence [23] with the incidents, officers, and their job tasks, the overall design of the video and associated technology did not support this engagement throughout the job processes. This often led to frustration, an absence of closure, and a lack of satisfaction for some staffers. UK3-1 explained that the operators rarely hear what happens after they stop following an incident, a fact bemoaned by many:

*“What is so frustrating...sometimes you think to yourself ‘I’ve seen all this incident but I don’t know what happens.’ You see people get arrested and you never know if they’ve been charged.”* [UK2-2]

*“You never really knew what happened. You’d pass the job down to the police station and that’s the last you saw of it.”* [UK5-4]

In fact, although knowing the outcomes of the incidents on which they had worked was not essential for their functional job tasks, workers overall were curious to know the results of their labors, and derived satisfaction from learning the effects of their actions. UK3-5 stated that he received the greatest job satisfaction from knowing that his observations led to arrests. The ways in which staffers came upon this information, however, was generally serendipitous, unsystematic, and ad hoc. Their information was largely word-of-mouth and dependent on being in the right place at the right time:

*“What I do like most is the fact that we assist the police and assist with evidence against criminals, gives me a sense of satisfaction when something you hear over the radio and something that you have done has resulted in someone being caught.”* [UK2-4]

On occasions when operators had contact with police officers, they were also sometimes able to find out about incident outcomes:

*“Now when you come here, you might bump into [the officer] in the corridor, ‘Hey, what on earth happened to that job the other day?’ And they’ll tell you what really happened.”* [UK5-4]

However, operators generally described the follow-up process as difficult, requiring effort outside of their or the officers’ responsibilities. Given the busy nature of their jobs and the volume of incidents, they also described the word-of-mouth process as simply being impractical for informing themselves about more than a few isolated events:

*[UK5-1] “It’s more that we haven’t got time to ask [the officers] unless it’s a really interesting case. And they haven’t got time to tell us...”*

*[UK2-2] “If you really wanted to, our police officer here would find out [about the result of an incident]. But it happens every day or every night so you could only ask occasionally, it would be too much.”*

The importance of “making a difference” to CCTV operators (and managers) is also illustrated by the visibility of performance metrics in their work environment. Several sites also displayed news articles and awards praising the performance of the site or operator(s) with them.. Of the five CCTV control rooms visited, four of them incorporate some sort of public display (Figure 5). These displays (both electronic and dry-erase) show statistics such as response times and the number of arrests in which operators provided assistance over some time period. In at least two rooms, operators are divided into “teams” by shift, with statistics presented on the displays by team. According to one manager, “I like to think there is camaraderie sort-of competition” [UK5-1]. In addition to visually quantifying the extent to which the operators are making a difference in crime reduction, the displays also serve to track arrest targets imposed by external agencies, such as the city councils that fund them.



The use of video technologies by CCTV operators leads to an interesting tension by first fostering a strong sense of engagement with the incidents and people involved, and then providing little means by which the operators can follow up on the events. It is apparent from the CCTV operators' comments that when they serendipitously learn the outcomes of their work, they experience a strong sense of accomplishment and pride. However, while the technologies they use support their work activities, the systems offer little or no support for this type of discovery and follow-up, leading to diminished job satisfaction and yielding frustration.

## DISCUSSION

The use of video is rapidly changing many aspects of law enforcement processes, and these changes are reflected in how law enforcement workers engage with video in their activities. Our study reveals some of the ways in which worker practices are affected as video technology is introduced and points to ways in which these technologies are both beneficial and limited. To paraphrase the statement from chief officer Neville presented in our introduction, an important challenge at this point is not to introduce further technology, but to work on integrating the technology into processes in such a way that makes them maximally effective. Our findings expose several ways in which video technology can introduce unexpected challenges into workers' jobs. In considering how to integrate these technologies into law enforcement work, we believe that several issues need to be considered in their design.

In the case of video analytics, it should be made clear that while participants were generally unhappy with the capabilities of the more sophisticated systems they had tested, they did see the potential value of these kinds of systems for aiding surveillance tasks. However, experienced video operators are in possession of observational skills and historical knowledge of their assigned areas that cannot be emulated by current offerings. Thus, the integration of video analytics into law enforcement poses especially high hurdles that cannot be addressed simply by rethinking processes and interaction design. Adopted analytics systems such as ANPR instead perform simpler tasks more reliably, complementing operators' specialized abilities rather than attempting to mimic them. Comments from our participants regarding performance problems such as false positives and negatives indicate that refinements are still necessary in video analytics algorithms and sensing. However, we also believe that it is worthwhile to consider how the rich, subtle, and complex expertise of human operators can be leveraged. Going forward, video analytics systems for law enforcement may benefit from flexible mechanisms that allow analytics to be integrated with human operators' experience and domain knowledge.

In addition, video needs to be considered not as a standalone medium, but as part of a complex ecosystem of data and artifacts that often need to be treated as parts of a

whole. While it is clear from our study that there is a need for interfaces that better support search, indexing, and browsing tasks, as law enforcement technologies move into the future, it will become increasingly important to consider how to integrate video data with other types of digital and physical artifacts in a flexible fashion. As our observations indicated, the collection of materials with which law enforcement workers deal can be quite heterogeneous, and the ways in which these materials are used together can be situation-specific. Recall the case of site US1, where the integration of digital video evidence into a system that had traditionally handled physical evidence would seem to necessitate a rethinking of the processes for storing and retrieving that evidence. In the case of US2, the incorporation of video and other recorded media within a large-scale organization that still uses paper and physical media as its primary mode of information exchange has engendered artifacts and practices that attempt to bring recorded media into this system. These artifacts take the form of printed summaries of digital recordings (line sheets) and hand-written annotations to mark important passages within those artifacts. We believe that a careful consideration of the work context in which video is deployed is as important as the improvement of technologies and interfaces for handling video. In some cases, technological support can assist tasks such as search/retrieval, but in other cases, redesign may need to occur at the level of workflows and job responsibilities.

Systems for supporting law enforcement should also recognize that interacting with video is highly experiential, creating a strong sense of engagement and involvement with the events depicted. Our participants felt a certain sense of investment in the incidents that they observed and acted upon. However, a the lack of system support for following up on events led to frustration over being denied the opportunity to find out about the results of their efforts. The design of future systems may benefit from supporting this engagement not only during real-time surveillance activities but throughout the process as a whole.

## CONCLUSIONS AND FUTURE WORK

The increasing adoption of video technologies within the domain of law enforcement has not been without controversy regarding its effects on crime rates and privacy. Despite these concerns, law enforcement agencies continue to invest in increasing amounts of technology to support the use of video. This work contributes an end-to-end understanding of how the use of video is shaping work across a variety of contexts and roles within the domain of law enforcement. Through an extensive field study of several types of law enforcement facilities that employ video technologies, we examined the many ways in which video affects roles within several phases of law enforcement. We uncovered emerging practices around the surveillance and capture of video, as well as subsequent tasks such as archiving, indexing and retrieving video, and the ways in which these tasks affect workers' roles. Our

results point to breakdowns in how video is being integrated into work processes at several stages within its life cycle. Our findings suggest a need for further consideration not only of the technical capabilities of video tools but also of how they affect the roles of the people using video to carry out law enforcement tasks .

There are several current and future directions for this research. We are currently incorporating the results of this analysis and other data from our investigation into the design of new applications and interfaces to support the use of video in law enforcement. We are also integrating additional law enforcement agencies into our field study, including several facilities that currently do not employ video for any purposes. In examining these sites, we aim to understand whether and how video could be integrated into their processes, and what benefits and problems it may yield through its inclusion. Finally, we are also conducting ongoing analysis of our data to understand the role that video plays in work tasks in still greater depth, in particular focusing on the ways in which video affects communication and collaboration between and within various law enforcement agencies.

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