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Understanding the role of case management systems in criminal investigations

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ABSTRACT

Case management systems (CMSs) are essential to modern criminal investigations but remain underexplored compared to systems for predictive policing and digital forensics. This study examines how investigators use CMSs, which capabilities remain insufficient, and how these systems can better support their work. Through interviews with practitioners across European jurisdictions, we identify an investigative workflow of six concurrent dimensions and propose a two-tier model distinguishing preparation and exploration for knowledge discoveries. While CMSs effectively manage actions and decision-making, critical gaps persist for knowledge discovery, such as text analysis, hypothesis testing, and information retrieval. We derive functional requirements by workflow dimensions, offering guidance on which capabilities should be embedded in core systems and which are better delivered as modular services. These findings inform the design of CMSs that combine stable infrastructure with flexible tools.

1. Introduction

'The world runs on information systems' (Valacich et al., 2022), a reality equally evident within law enforcement agencies. These systems both shape and reflect organizational priorities. Predictive policing has often been prioritized over criminal investigation, and digital forensics systems over *Case Management Systems* (CMS), which remain underexplored.

This reality represents a research gap at the intersection of investigative practices and the CMSs through which they are operationalized. Consequently, criminal investigators experience ineffective manual processing of information (Gianola, 2020) and insufficient access to relevant information (Partridge and Zaghloul, 2023). These issues contribute to information overload (Rossmo, 2021) and ultimately increase the risk of unsolved cases. Police systems used for criminal investigations have so far been insufficiently explored despite the potential for improving investigative practices (Bjelland and Dahl, 2017). Understanding when technologies are most effective during investigations and how they can be optimized for improving case resolution is needed (Prince et al., 2021).

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1.1. Predictive policing over criminal investigations

Over the past decades, several policing strategies have emerged and evolved, such as problem-oriented (Goldstein, 1979), evidence-based (Sherman, 2017), and intelligence-led policing (Ratcliffe, 2003). Strategies intended to predict and prevent crime (Williamson, 2008; Campedelli, 2022). Methods referred to as data-driven policing within data science disciplines (Lee et al., 2024; Van De Sandt et al., 2021), including algorithm-based systems such as COMPAS, the Chicago Heat List, and PredPol. Despite significant investment, predictive systems such as hotspot mapping and risk scoring often serve mainly as managerial tools to demonstrate proactivity rather than improving outcomes (Benbouzid, 2019). Such tools have delivered limited success and reinforced systemic biases and flawed assumptions (Angwin et al., 2022; Campedelli, 2022; Heaven, 2020; Saunders et al., 2016).

While considerable focus has been placed on predictive policing, CMSs that support criminal investigations have received less attention. A robust investigative capability and higher rates of solved cases can generate crucial data and insights that inform predictive models, which are only as good as the evidence that underpins them. Improving CMSs may therefore have a more direct and lasting impact on investigative effectiveness, clearance rates, and the overall quality of policing than further incremental enhancements to predictive policing.

1.2. Digital forensics over CMS

Beyond predictive policing, the dominance of digital forensics systems and models shaping investigative frameworks has overshadowed theoretical development of CMSs in criminal investigations. This represents a fundamental inversion: allowing digital forensics to dictate the investigative process rather than serving it.

The scale of this issue is evident in the proliferation of digital forensics process models. More than 60 digital forensics process models have been proposed over the last 20 years (Stoykova, 2022). Literature and training focusing on computer, mobile, and multimedia forensics (Årnes, 2017, 2022) have created parallel frameworks like the *Digital Forensic Process* (Faglien, 2017) and the *Cyber Investigation Process* (Sunde, 2022), often without connecting to criminal-investigative workflows. As Stoykova (2022) observe, many models do not differentiate between investigative objectives and digital forensics methodology, resulting in frameworks that are unfit for investigative practice.

The inversion problem originates from the failure to recognize criminal investigation as the superordinate domain with its own established methodology. When proposed models stem from digital forensics and define investigative structure, this undermines the holistic nature of criminal investigation. Standards for CMSs should therefore arise from the domain of criminal investigation with the objective of facilitating systems designed for investigative needs. Digital forensics is one information source among many, such as police interviews, crime-scene reports, and financial records. CMSs are therefore as critical as digital forensics systems because their objective is to enable the synthesis of information into coherent investigative knowledge, functioning as an orchestra that consolidates diverse sources into unified workflows. This distinction underscores why their development warrants greater attention.

1.3. Aim and research questions

The predominant attention to predictive policing and digital forensics has overshadowed the need for CMSs. While digital evidence provides raw information, CMSs are essential for transforming that information into coherent investigative knowledge.

By CMSs, we refer to a digital platform that serves as the central workspace for criminal investigators offering configurable modules including but not limited to action allocation, decision-making, information analysis, information retrieval, and hypothesis development. The primary objective of a CMS is to preserve the chain of custody while facilitating knowledge discovery by synthesizing information from any source. CMS operate alongside of other systems such as police registers, document handling systems, and visualization tools.

This study aims to explore the application of CMSs in criminal investigations and identify opportunities for their further development to meet operational and analytical needs. Specifically, we aim to describe how existing CMSs support investigative work, identify opportunities to expand their capabilities, and articulate requirements for next-generation systems that better integrate diverse sources of information. We address the following research questions:

- What is the purpose of CMSs utilized in criminal investigations?
- What is the workflow within these systems?
- How are they designed to support information analysis?
- What unmet needs and core requirements exist for next-generation systems?

In this study, we propose the six-dimensional concurrent investigative workflow, the two-tier prepare–explore framework for information analysis, and a requirement list for CMSs. These contributions aim to inform the development of more effective and efficient systems to support investigative practice.

The remainder of this paper is structured as follows. Section 2 reviews prior work on this topic. Section 3 describes our methodology, followed by our findings in Section 4. We then outline core requirements for bespoke CMSs supporting criminal investigations in Section 6, before concluding in Section 7.

2. Related work

'The investigation of crime is fundamentally a form of information work' (Innes, 2003). A detective works with the collection, interpretation, and dissemination of information (Rønn and Hald, 2013) with the purpose to 'obtain the necessary information for deciding whether an indictment should be preferred, and to serve as preparation for the proceedings in the court's trail of the issue of guilt' (The Norwegian Criminal Procedure Act §226). While substantial documentation of investigative methods and processes exists (Greenwood, 1979; Innes, 2003; Newburn et al., 2012; Fahsing and Ask, 2016), empirical studies of how CMSs align with investigative practices remain limited, despite growing reliance on digital tools.

CMS for criminal investigations have evolved from basic information management to sophisticated expert systems. Gottschalk and Dean (2010) describe four stages: end-user tools, expertise systems, shared repositories, and problem-solving expert systems. Contemporary CMS represent Stage 4, turning information into evidence through a comprehensive understanding of law enforcement practice.

Early pioneering work by the Ottawa Police Service demonstrated the potential of knowledge-based technologies in criminal investigations (Brahan et al., 1994). Recognizing that police services primarily focus on gathering and processing information to solve and prevent crime, they developed a system supporting data collection, suspect profiling, information retrieval, modus operandi identification, pattern recognition, reporting, and visualization. Although experienced investigators contributed to its design, the project focused mainly on technical functionalities rather than mapping workflows or evaluating how practitioners used the system.

2.1. Case management systems and adoption challenges

This historical foundation has evolved into a commercial landscape with multiple CMS products, including *Kaseware*, *Case Closed Software*, *Case Builder*, and *PowerCase*. These systems are often built on practical experience, as reflected in marketing claims such as *"professionals who understand your needs—because we've done the job"*.[1] However, Koper et al. (2014) document widespread adoption of such technologies in policing while noting a troubling disconnect between implementation and evaluation, with little empirical assessment of their impact on investigative outcomes.

A persistent theme in the literature is the gap between what CMSs are designed to do and how they support investigative work. Adderley and Musgrove (2001) examined software in crime analysis and found that case management tools helped prevent information overload and facilitated data transfer between systems. These tools supported functions such as action management, document handling, searches, link analysis, and visualization. However, the analysis focused on system capabilities rather than whether these functions met investigators' needs, relying mainly on developers' accounts instead of systematic user evaluation.

More recently, Burcher and Whelan (2019) showed that capability gaps persist. Intelligence analysts reported challenges with siloed information storage, leading to incomplete analysis and doubts about accuracy. All participants cited data overload from inadequate software, underscoring the ongoing disconnect between system capabilities and users' needs.

Such mismatches echo concerns examined in Requirements Engineering, which studies how stakeholder goals translate into verifiable system requirements (Dick et al., 2017). When this translation fails, for example because needs are weakly elicited or trace links are lost, CMS solutions may become functionally rich yet remain misaligned with investigative practice.

2.2. Technical approaches to investigative support

Various technical approaches have emerged to address the computational challenges of criminal investigation. Maller (1996) highlighted the inadequacy of databases for handling the complex, time-varying relationships in criminal cases. Later, Chen et al. (2003) presented an information-sharing application connecting multiple databases through a single interface and search tools. While their study focused on organizational information retrieval rather than investigation management, they also identified large collections of unstructured text with rich information not captured in structured fields and recommended data mining and linguistic analysis capabilities.

Van De Sandt et al. (2021) proposed the *CSAE framework* (Collect, Store, Analyze, Engage), a data science approach for criminal investigations aimed at transforming evidence from raw data into actionable intelligence. However, such frameworks remain primarily digital forensics-focused and lack integration into broader criminal investigation workflows, highlighting the challenge of bridging technical capabilities with investigative methodologies. Closer aligned with fundamental investigative reasoning, Bex et al. (2007) developed *"sense-making"* software supporting core investigative reasoning processes. Their approach allows investigators to visualize thinking and develop hypotheses through abductive logic, directly addressing the cognitive aspects of investigative work. Such developments highlight a shift from purely managing information toward supporting the cognitive processes of investigative reasoning, recognizing investigation as fundamentally a knowledge work-process.

[1] Kaseware. (n.d.). About Us. "Professionals who understand your needs—because we've done the job".. Retrieved 2025-07-04, from https://www.kaseware.com/about.

2.3. Regulatory requirements and guidance

Official guidance and regulatory frameworks provide important context for understanding CMS requirements and limitations. A public inspection of law enforcement agencies found that information management systems facilitate effective investigations by linking information (HMIC, 2015). It emphasized the importance of having "relevant information available to the right person at the right time" and concluded that systems need better information transfer to give officers broader access.

National Police Chiefs' Council (UK) procedures state that successful investigations require methodical management of all material to ensure effective direction and timely disclosure. Action management ensures that all lines of enquiry are systematically followed and documented, creating clear audit trails of progress (NPCC, 2021). These requirements highlight investigations as processes that depend heavily on effective CMS functionality.

The Campbell report (1996), reviewing the Bernardo investigation, made establishing a CMS a key recommendation. Such systems must give investigators the tools to organize, manage, retrieve, and analyze large volumes of data they conclude.

Requirements engineering highlights the need for strong traceability and clear qualification strategies. Each requirement should have an acceptance criterion and be linked many-to-many across abstraction layers, enabling impact analysis, audit trails, and defensible disclosure (Dick et al., 2017).

3. Methodology

This study employed an exploratory qualitative approach based on eleven in-depth interviews conducted between December 2024 and April 2025. Interviews lasted 40 min to nearly two hours. Transcriptions were completed by April, followed by iterative analysis in May 2025.

3.1. Participant recruitment and selection

Participants were recruited through two strategies: international law enforcement networks and academic collaborations. Only the law enforcement channels yielded participants. All received detailed information sheets and signed consent forms before interviews.

The sample comprised four Senior Investigator Officers, one Officer Manager, two Detective Constables, and five Operational Analysts from agencies in Norway, Sweden, France, and the UK.

3.2. Interview preparation and guide

We developed a semi-structured interview guide informed by an extensive literature review of criminal investigations and information systems. This review, guided by the question *'What is the understanding of criminal investigations within the domain of information technology systems designed to support information management?'*, provided preliminary findings that shaped our question design.

The interview guide covered three themes: *criminal investigation practices*, *information science perspectives*, and *computational methods*. The full guide is provided in the Appedix.

3.3. Analytical framework and coding

Our analytical framework combined principles from Gioia et al. (2013)'s inductive coding and the structured qualitative approach of Tjora (2012). The coding process involved three stages:

1. **Initial Coding:** We conducted close empirical coding using informant terminology and tested each code for inductive validity. This yielded 576 data segments linked to interview contexts.
2. **Categorization:** Segments were grouped into 14 categories and 105 sub-categories by systematically asking, *"What is this about?"* This process was guided by our research questions, with focus to purpose, workflow, methods, and functional needs related concepts.
3. **Aggregation:** Categories were synthesized into higher-order conceptual dimensions relevant to our research questions, and a relational dataset was created to link codes to interview questions.

3.4. Requirements

Following requirements engineering principles (Dick et al., 2017), we identified and grouped functional requirements from the interviews and organized them by investigative workflow and functional area. For each, we assessed whether it was implemented, partially supported, or absent in current systems. This approach provides a structured view of practitioner-defined needs and their support in existing CMSs.

4. Results and analysis

This section presents findings across four aspects: purpose, workflows, analysis, and functional needs. Together, they address our research questions. The results synthesize all interviews and should be seen as reflecting combined systems and practices rather than any single platform.

4.1. System purposes: information collection and processing

Our findings show that CMSs serve two core functions in criminal investigations: collecting information and processing it. The collection focuses on investigative actions and work allocation, while processing involves analyzing information to produce knowledge. An Operational Analyst explained the benefit of applying a CMS:

> *'We have control over how we collect [data], in what manner, and what output we get from it, and we then have the opportunity to process the information in this system.'*

The analyst also described how processing data in the CMS improves structure and accessibility:

> *'[the CMS] helps me keep the structure of information. I know where I have it. I usually compare it to moving into a kitchen. I have a glass, there are the plates, and when I'm told to set the table, it happens quickly... It helps me see patterns... It helps you see things that are not there, but that should have been there.'*

A Detective Sergeant viewed the CMS as a necessity, and elaborated on the collection of information through actions and work allocation:

> *'everything is generated through [the CMS] and all the actions... I can't imagine how we would work without that system being in place...'*

> *'you'll be allocated specific actions. And the action will have details... What we're looking for... their originating document... any linked actions to it as well, and any associated documents and any attachments.'*

Processing collected information was described as a manual task that produced structured tabular datasets. These datasets functioned as information storage, substituting for human memory and providing a case overview:

> *'...if we don't have the system, then we are completely dependent on our, or we are limited by our cognitive abilities as humans... [the CMS is] the only place where investigators can have control over their criminal case without relying on memory.'*

We find that CMSs serve two core purposes: the collection and processing of information. The collection function enables control through action management, while processing creates a structured database that extends human cognitive capacity and facilitates information accessibility.

4.2. The six-dimensional concurrent investigative workflow

Based on our analysis, we identified a six dimensional workflow characterizing CMS use in investigations: action and work allocation, case database generation, knowledge discovery, decision making and documentation, quality assurance, and communication and collaboration.

These dimensions form a workflow in which any can occur in any order. In addition, we identified initialization and case closing as separate dimensions that define the start and end of investigations. Each dimension is described in the sections that follow.

4.2.1. Initialization

Initiating a criminal investigation in a CMS involves creating a new case and establishing user access. Some users reported using templates that predefine case details such as document types, action classes, and sub-projects. Another essential step is recording the initial complaint and generating the Document One policy file, which serves as a protocol document. An Officer Manager explained the use of the Document One file as part of initialization:

> *'There is a Document One, and every incident has a policy file. It basically starts off - do this. The document One... starts off with what the incident is about. Who's all the staff... Crime Scene manager, House-to-house [officer], and enquiries parameters... administrative information... anybody coming onto the enquiry to work on it knows, they look at that [Document One file].'*

4.2.2. Action and work allocation

Once a CMS project is established, investigators are granted access, and multiple activities begin in parallel. Action and work allocation emerged as a core function across all systems. Creating, assigning, logging, prioritizing, and tracking actions were central tasks used not only for collecting information but also for documentation, quality assurance, decision making, and analysis. A Detective Constable explained the use of actions:

> *'We use it every single day... I am allocated actions. So, for my inquiry at the moment, I have 30 active actions. It's a murder from 1994. Obviously, they've prioritized actions [as] low, medium, and high. And so I am basically working through those actions.'*

4.2.3. Case database generation

Alongside managing actions, investigators build a case database by processing information, a core purpose of CMSs. Interviewees described this as populating the CMS, or filling an initially empty system with content. The process involved several specialized roles, such as typist, registrar, indexer, document reader, analyst, and officer manager. An Officer Manager elaborated on the process:

> *'You've got a registrar who's an indexer, and then once they've done their part, it goes to the reader, and they'll read it and then index it again, so you'll have more than one indexer around... any nominals they need [will lead to] raising actions [like], make the links [or] create the telephone [numbers].'*

We view this stage of the workflow as a preparatory phase that enables knowledge discovery. We further elaborate on this dimension in the later description of the Prepare-Explore framework.

4.2.4. Knowledge discovery

When case file documents are added to the CMS and organized into a database, they support knowledge discovery. Interviewees described using the CMS to digest information, assess evidence, build timelines, map involvement, and brainstorm findings. Some generated and tested hypotheses, though only one system included dedicated hypothesis modules. Investigators also synthesized information and created thematic summaries to support their work. One Detective Constable explained using the CMS for research and interview preparation:

> *'you can obviously use it for research and do a lot of research prior to going to speak to someone and just to see if they're sort of linked in any way.'*

We view this as a post-phase dependent on case database generation, and we will elaborate on this dimension as part of the Prepare-Explore framework.

4.2.5. Decision-making and documentation

Another dimension is decision-making and documentation. CMSs act as decision-tracking mechanisms. When investigators skip a witness interview because the person is deemed irrelevant, the system records the rationale. This creates an audit trail showing not only what actions were taken but why decisions were made. An SIO described this:

> *'I put my rationale in for why [we are] no longer doing that. So that it's all transparent.'*

Our interviewees described several techniques for decision-making, both within and outside the CMS, including daybook recordings, decision logs, daily briefings, and policy files. However, we found divergent experiences with decision tracking. While some users successfully documented investigative rationales as described above, others encountered limitations in their systems. One Operational Analyst described this challenge:

> *'It's more of a document management... Document management with timestamps, where I can see roughly what has been done in an investigation. A lot of interviews have been held. We have written a lot of memos, and we have gathered information that has become documents. But then, why? Why was it done? That doesn't appear in the system.'*

This contrast reveals a gap in CMS functionality. While all systems document evidence and track actions, only some capture the decision-making rationales that provide transparency and accountability.

4.2.6. Quality assurance

Another recurring task is quality assurance, a fundamental part of investigations. Investigators reported proofreading documents, checking for missing information, and identifying discrepancies to follow up. Any such discovery often leads to new actions, as an Officer Manager explained:

> *'we have a plan of action for where we're going with the inquiry... So it's very rare that that things get missed... So the way you describe it to me is, is it correct that the way you do your reliability check is closely linked to a new action? Yeah, Yeah. It's a new action.'*

An SIO similarly described how reviewing statements routinely leads to further investigative steps:

> *'a common thing for me [is] to be reviewing [statements], I might look at the statement [deciding] I want more details... So the statements can come in, and I would then speak to the office manager and say I want more information about that, so generate an action to TFST, which is to take a further statement.'*

Quality assurance emerges as an integral step that drives investigations forward. Rather than merely validating work, it also identifies new leads and generates further actions, demonstrating its role within the investigative workflow.

Table 1
Summary of workflow dimensions within Case Management Systems and examples of activities.

Dimension	Example of activity
Initialization	Create new project from template
Action and work allocation	Allocate actions
Case database generation	Create nominals
Knowledge discovery	Interview preparation
Decision-making and Documentation	Log rationale
Quality assurance	Identify missing information
Communication and dissemination	Briefings, E-mailing
Case closing	Build case protocol

4.2.7. Communication and dissemination

Communication and dissemination are critical to collaborative investigations. When investigators find relevant information or new leads, immediate sharing is essential. We found multiple communication pathways. While formal reports provide documentation, the fast pace of investigations demands quicker exchanges. Investigators often shared findings before reports were finalized. Some CMSs offered basic email sharing but lacked purpose-built collaboration tools. The action and work allocation module served as a hub for written updates on task status. However, verbal channels dominated daily communication through calls, meetings, and briefings. The urgency of critical discoveries often bypassed digital systems, as one Operational Analyst explained:

> *'then I would run around to everyone and say - I have found it... No, there isn't [any other way. Or,] I should be able to create a new task. Like, I have found that Petra is near the crime scene. Now we have to collect her call records.'*

4.2.8. Case closing

Case closure marks the transition from active inquiry to legal proceedings. Whether resolved or unsolved, cases require systematic finalization in the CMS to prepare for court or archiving. This involves creating a comprehensive case file protocol that organizes all materials into a structured format. The protocol both underpins legal proceedings and bridges investigative work with the justice process. One SIO described this as fundamental to her role:

> *'I read everything and create a structure in the investigation protocol so the prosecutor and lawyers, and the court can learn and understand the case.'*

Most CMSs lack explicit case closure functions. Instead, projects are simply marked closed without formal procedures.

In this section, we have presented a six-dimensional workflow that challenges traditional sequential models. Unlike linear processes, it operates as an interconnected system where any dimension can trigger another. Action and work allocation is the central nervous system, while case database generation facilitates knowledge discovery. Decision-making, communication, and quality assurance weave throughout, ensuring transparency, collaboration, and identification of information gaps. See Table 1 and Fig. 1.

4.3. The two-tier prepare-explore framework for information analysis

In this section, we present the two-tier prepare-explore framework for information analysis. We identified a sequential methodology embedded as part of the wider investigative workflow. This process transforms raw information into actionable knowledge through two phases: Preparation and Exploration, corresponding to Case Database Generation and Knowledge Discovery dimensions within the six-dimensional workflow.

4.3.1. Preparation: populating the database

The analytical capabilities of CMSs depend on the quality and structure of their data. This preparatory phase involves investigators manually indexing and organizing case materials, creating the foundation for later exploration and discovery. It includes importing and sorting documents, reviewing and marking them, creating and enriching nominals, linking related entities, and validating the process. The preparatory phase consists of six steps presented in the following.

The *first* step involves categorizing documents to prioritize them for further analysis, as one Operational Analyst described:

> *'...for the documentation, it is not only the document title, but sorting the type of document. That is probably the first thing I do.'*

An Office Manager similarly explained this using forensic reports as an example:

> *'You want to be able to keep your forensic reports in one place so you can register them to a category, which is what I normally do.'*

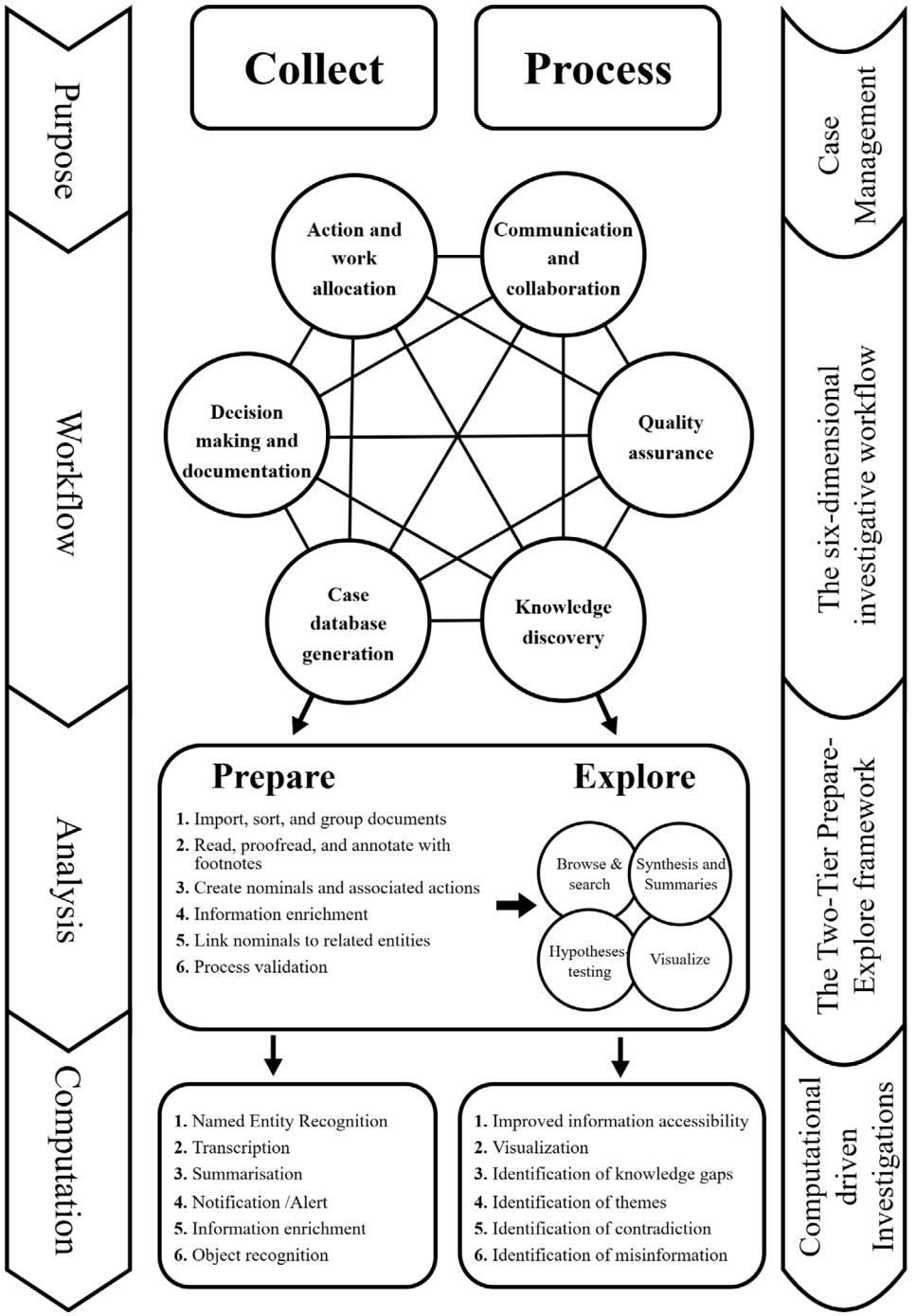


Fig. 1. Findings: Purpose, workflow, analysis and computation.

Secondly, after categorizing, documents are read, proofread, and marked up for quality assurance. A marking creates a footnote containing instructions on what needs to be done. If discrepancies or missing information are found, new actions are raised. The Officer Manager oversees this process, a role an SIO described as essential. This stage prepares for creating nominals and entities. In two of the CMSs we studied, this workflow was well established. A Detective Constable explained:

> *'that statement would then be read, proofread and marked, and obviously any nominals would be linked. Yeah, indexed. Yeah....they would check if that would generate any further actions and basically continue with the inquiry.'*

An SIO described populating the CMS database as a fast-paced process:

> *'They're always trying to catch up with information that is being [collected during the] inquiry. That it's so fast-paced for the [CMS]... For them, they are always playing catch-up... [it is] quite a significant pace, with new information coming in.'*

A broad set of terms described this process: populate, tag, mark, footnote, highlight, register, break down, decompose, index, and create nominal or entity records. While this variety shows how thoroughly the work is described, it can also create communication barriers among users. Ultimately, the goal is to convert textual mentions into structured database objects.

Third, investigators create nominal or entity records, converting mentions in documents into structured entries. The *fourth* stage involves updating nominal records with identifying details, such as dates of birth, by conducting database lookup. An Operational Analyst explained:

> *'We have these lookups that you can do, [we do] lots of queries for personal numbers, bank accounts, and phone numbers.'*

The *fifth* stage involves nominal linking. Once a nominal or entity is created, it can be linked to other records such as phone numbers or locations. An Office Manager explained:

> *'... and that's also his home address. That has been, he's an associate of [name of person]. That's his brother, and he's the owner of the car. So all these, all these different things here, these are all different indexes, so that's a digital comms index. So, in there we can have like mobile phones, IMEIs, e-mail addresses. So we create them... we can link to other indexes like person to person, person to digital comms, or person to home.'*

The *sixth* and final stage is process validation to ensure no nominals or information are missed during database population. This responsibility typically falls to the Officer Manager:

> *'When I come to approve everything, when it comes to my queue, I know [name of person] is here. He has given a statement, so what I would do is check to make sure his statement, that they've been annotating, covers his involvement.'*

The preparation phase, referring to populating the case database, involves importing, sorting, and grouping documents; reading, proofreading, and marking up; creating and enriching nominals or entities; linking related records; and validating the process to ensure completeness. See Fig. 1 for an overview of how this process aligns with knowledge discovery.

4.3.2. Exploration: search, synthesis, visualization, and hypothesis testing

Preparation provides the foundation for subsequent exploration. While preparation is largely sequential, exploration relies on interconnected, non-linear activities. Four methods support discovery: browsing and searching, synthesis and summarization, visualization, and hypothesis testing.

First, information discoverability through browsing and searching is a key part of using a CMS for knowledge discovery. A CMS database supports discovery in multiple ways: users can actively search for specific content or passively browse nominals and documents to build understanding. A Detective Constable described this process:

> *'[I'm] basically, looking at nominals, if they've maybe mentioned somebody in their statement, I would then look for that nominal... [I] research to make sure that I know everything before [I] speak to somebody...'*

Second, information synthesis is another exploratory method, combining nominals and details from multiple documents to generate new insights. One SIO described his role as synthesizing colleagues' work into analytical products that address specific investigative questions or themes. This process often produces summary reports that serve as efficient retrieval tools. As one interviewee explained:

> *'there are summaries that you can search so it goes a bit faster than... reading all the documents. It makes it a bit easier to filter out the material, like based on the question you have.'*

These summaries help investigators quickly retrieve relevant information.

Third, visualizations were used to gain new insights. An Operational Analyst described using the CMS for multi-perspective viewing and as a source for external visualizations. Within the CMS, information could be viewed in tables sorted by date and time, or relationally across nominals. Two CMSs had previously supported geographic viewing. However, the analyst mainly relied on more advanced external tools and saw the CMS as part of a broader ecosystem, not a standalone platform.

'[the CMS] is just a support tool for other analysis tools that do it better'

Fourth, hypothesis testing. All interviewees reported generating and testing hypotheses as part of their work. However, only one CMS included integrated hypothesis modules. One SIO explained that hypotheses were typically developed through brainstorming sessions rather than within the system:

'All along the process, we do, I do [as the SIO] multiple brainstorming [sessions] with my colleagues to generate some hypotheses, testing those, then.'

Another SIO noted that hypotheses were documented in briefing papers:

'... [so it] comes to a point where we would write a briefing paper outlining our concerns and as part of that, we would include our investigative hypotheses.... What do we think has happened or might have happened'

The exploration phase includes browsing and searching, synthesis and summarization, visualization, and hypothesis testing. See Fig. 1 for an overview of how these activities align with case database generation and the overall workflow.

The preparation and exploration phases reveal a tension between investigative requirements and current CMS capabilities. While preparation involves systematic processes to transform raw information into structured databases, and exploration relies on advanced analytical techniques, many activities remain manual and time-consuming. Workflows from document processing, like entity creation to visualization and hypothesis testing, highlight opportunities for computational support. This gap between investigative needs and available functions prompted us to examine specific requirements that could help automate and improve CMS workflows.

5. Functional needs

Based on our interviews, we identified 13 functional needs that we argue should be embedded into CMSs. We found four needs related to Case Database Generation, seven needs related to Knowledge Discovery, one need related to Decision-making and Documentation, and one need related to Communication and Dissemination. We examine these needs in detail in the subsequent sections by initially presenting each one individually, followed by a discussion of whether each component should be integrated into the system or function as an external module.

5.1. Case database generation

Our interviewees highlighted the need for better information management, including database integration for lookup and automated enrichment from external sources:

'Obviously, we want a database where we see everything... But we have to start from the beginning [for every new case]. It is inefficient. But in the best scenario, I should see that an [account], in the interrogation and an IMEI is [linked in a database], that would maybe halve [the time for] my criminal investigation.'

CMSs offered import and export functions for both structured spreadsheets and unstructured documents. However, one interviewee reported experiencing information overload when importing large datasets, highlighting the system's data handling limitations and its inability to manage such volumes effectively:

'There are automated import possibilities... That can make everything get lost.... I can use an example from a real case... someone who imported. I think it was 5000 financial transactions. Everything that he had done on his card, probably for the last 10 years, went into the incident tab, then everything disappears.'

Several interviewees identified enhanced text analysis as crucial for investigative effectiveness. The automated generation of nominals proved to be insufficiently developed across all systems. While one CMS was in the process of developing entity extraction capabilities, another had attempted implementation with disappointing results, as noted by a Detective Constable:

'It can try to extract typical identifiers like phone numbers and social security numbers and such, but it's so poor that it's rarely used.'

An Operational Analyst suggested developing a workflow to create entities and links automatically:

'a natural workflow, where you get this [document] broken down as automatically as possible, and [where] we get our information broken down into objects and connections to relevant information'

This lack of automation increased the burden of manual analysis, as one SIO explained:

'we can build timelines, we can cross refer, we can do probability analysis, we can do offender profiling, but it is all manual.'

Current CMSs do not process multimedia. The rise of surveillance footage has created demand for automated analysis. One Operational Analyst described how time-consuming manual video review is:

'searching in surveillance footage, maybe like, you have a description of some person or something, you know those kinds of things, so you don't have to watch with your eyes all the time'

Investigators saw automated object recognition in media files capable of reducing manual effort.

5.2. Knowledge discoveries

An Operational Analyst noted that structured hypothesis management would improve investigations, arguing that current systems lack integration of established investigative practices:

> *'...[We need to] work with hypotheses in a structured way, [were] you formulate your hypothesis, then it's clear what the information need is and that you follow up and document what that hypothesis lands on, after you've done your information gathering... [otherwise] I go down all branches [because] I am curious about everything, but lose myself a bit.'*

Users also highlighted the need for better information access and retrieval. Search functions are central to investigations, but existing techniques were modest. The most advanced searches relied on word proximity, synonyms, phonetics, or stemming. Some systems used simple rule-based methods, such as dictionary lookup for drug or weapon terms, but these remained rudimentary. Only one CMS supported search in unstructured police reports, and two CMSs were limited to search in the indexed fields, as explained by an Operational Analyst:

> *'So you can't search in free text in the documents? No. I can search headings... [this] presupposes that everyone is very structural in the heading for it to be traceable.'*

One SIO mentioned the need for automated summaries and highlighting of contradictions within police documents:

> *'I want there to be something to be able to just pull out and summarize. Highlight things that should have been clarified that weren't clarified or that are contradictory.'*

The SIO also suggested automated information interpretation and saw this as a potential way forward for CMSs:

> *'It's not an interpretive tool. I can base my interpretation on the data. That itself offers little in the way, it will just present the information to me for human analysis to take place. It will not make assessments. It doesn't have any sort of artificial potential, which is where I think that's what I see, [as] the future of this.'*

One interviewee mentioned the ability to identify knowledge gaps:

> *'I think that one day there will be a product allowing [us to] make an assessment on where the gaps are, because if a computer program can look at that and say, here's where the knowledge gaps, here's where the data gaps are, then we can make the best value use of our investigators.'*

Investigators saw visualization as a critical gap in CMSs. While current systems excel at tabular presentation, they lack visual perspectives essential for pattern recognition. Users requested timeline views, relationship mapping, and geographic displays. An Operational Analyst explained this limitation:

> *'It's good with tables for us who are used to tables. And I see it as a good foundation... But, I do miss that you can easily switch between the different perspectives, those we often talk about are the timeline perspective, the relational perspective, the geographical perspective.'*

The lack of these features forces investigators to rely on external tools.

5.3. Decision-making and documentation

Traditionally, automated transcription has helped investigators prepare interview records. One SIO also noted its value for capturing briefings during an investigation:

> *'I think I would like to get out of the written concept of my duty. So I would like to have a recording tool, just speak, that's it, instead of typing.'*

5.4. Communication and dissemination

An SIO also highlighted the need for notifications to alert investigators when nominals are related:

> *'it should be able to come up to say. You might not know this because it's not immediately obvious, but did you know that [Person A] and [Person B] are, they're related.'*

A final overview can be seen in Table 2. Our findings of functional needs highlight a central challenge in CMS design: balancing comprehensive functionality with maintainability and adaptability. The requirements we identified, from notifications and alerts to multimedia analysis, span a broad spectrum of complexity and maturity. We use two orthogonal labels in Table 2: *Core* indicates a capability the CMS must support for day-to-day operation, auditability, chain of custody, and a defensible case record. *Modular* indicates an implementation that can be provided by an independent or external service rather than embedded in the CMS. A single requirement can be both Core and Modular, for example Named Entity Recognition, where the CMS must offer the capability while delegating method and compute to a service and storing canonical outputs in the CMS. We discuss the core set in the next section.

Table 2
Synthesis of functional requirements derived from interviews and analysis, categorized by proposed workflow. Core indicates a required capability, Modular indicates an independent implementation, and a single requirement may legitimately be both Core and Modular.

Workflow	Functional requirement	Status	Core	Modular
Initialization	Project configuration and user authorization	In place	Yes	No
Action and work allocation	Create, allocate, prioritize, and track actions	In place	Yes	No
Case Database Generation	Automatic import, sort, and group documents	Missing	Yes	No
	Automatic nomial/entity extraction and generation	Missing	Yes	Yes
	Automatic nominal/entity linking	Missing	Yes	Yes
	Database integration for nominal/entity enrichment	Partly	Yes	No
	Import and export of large datasets	Partly	No	No
	Object recognition in images	Missing	No	Yes
Knowledge Discovery	Hypothesis testing module	Partly	Yes	Yes
	Summarization of information	Missing	Yes	Yes
	Interpretation of information meaning	Missing	Yes	No
	Advanced retrieval and search capability	Missing	Yes	No
	Detection of contradiction	Missing	Yes	No
	Detection of knowledge gaps	Missing	Yes	No
	Visualization of information	Partly	No	Yes
Decision-making and Documentation	Transcription of briefings	Missing	Yes	Yes
	Record decision rationale and ensure transparency	In place	Yes	No
	Protocol building and court preparation	In place	Yes	No
Quality Assurance	Detection of missing information or discrepancies	Manually	Yes	No
Communication and Dissemination	Notifications and alerts	Missing	Yes	No
	Real-time collaboration among multiple users	In place	Yes	No
	Integrated modules for communication and collaboration	Partly	Yes	No
Case Closing	Generation of closing report and case protocol sharing	In place	Yes	No

6. Discussion

CMSs form the operational core of criminal investigations, from initialization to case closure. Capabilities, such as object recognition or named entity recognition, should remain separate services connected through a common interface. Embedding them too deeply makes replacement difficult, while loose coupling allows them to evolve without disrupting the core system.

Common functions like action tracking, entity generation, and linking form the baseline. Wants, such as visualizations, object recognition in images, and analysis of large datasets, warrant independent development, and therefore, such functions belong outside the core. Only standardized tasks should reside within the system; other capabilities connect through interfaces. As shown in Table 2, investigators' needs align with this perspective.

6.1. Pitfalls of building an all-encompassing CMS

Interviewees described how core systems often lacked essential capabilities, forcing them to rely on external tools and manual processes. Their experiences match software engineering evidence: Hasan et al. (2023) link monolithic architectures to rising maintenance costs, John and Bass (2001) show that poor separation of concerns undermines usability, and Dick et al. (2017) find scope creep inevitable when satisfying all stakeholders. Consolidating capabilities in one code base creates tight coupling, fragile dependencies, and significant overhead. In contrast, a modular, interface-driven design keeps systems stable and accountable while allowing investigative methods and technologies to evolve independently.

6.2. Text analysis and computational intelligence

Based on the needs identified in Table 2, there is clear demand for computational intelligence platforms that can process large volumes of diverse data and offer analytical tools to support investigations. The goal is to develop methods that aid both the preparation of structured information and the exploratory work of knowledge discovery, reflecting a broader shift from manual investigations toward computationally enhanced case management.

AI can serve distinct purposes. Some capabilities focus on creating structured, authoritative records, such as databases, provenance tracking, and knowledge graphs. These belong close to the core system. Others are more exploratory, supporting large-scale review and sensemaking across unstructured evidence, for example analyzing documents, surfacing connections, or clustering materials for assessment. While techniques like entity extraction or text analysis may apply in both areas, their role differs: one establishes the official record, the other enables discovery and hypothesis generation. Here, we outline requirements for platforms that accommodate both purposes.

6.3. Requirements engineering as a methodological foundation

Much CMS development has relied on domain expertise and iterative practice. However, our findings indicate that persistent gaps between system capabilities and investigative needs stem from challenges in translating complex workflows and tacit knowledge into verifiable requirements. This suggests criminal investigation systems can benefit from the structured approaches in requirements engineering.

We do not propose that requirements engineering replaces investigative expertise. Rather, it offers mature tools, elicitation techniques, traceability frameworks, acceptance criteria, and validation strategies to systematize how needs are captured and implemented. In this sense, requirements engineering complements the user discipline of policing. Instead of creating ad hoc methods for each project, CMS development could adopt these established practices to better align system design and investigative work. This integration would help address recurring misalignments, such as the lack of structured tracking of design assumptions, limited validation, and inadequate traceability, and support systems that not only process information but also enhance investigative reasoning and accountability.

Applying this lens to criminal investigation CMS reframes exhibits, actions, and hypotheses as derived requirements whose satisfaction and verification can be queried in real time, matching the accountability regulators expect of evidence-management systems.

6.4. Limitations

This study focused only on investigators' perspectives, excluding input from system developers and other stakeholders. The sample was small and concentrated in European contexts, which may limit generalization. Relying solely on interviews without observational data may also have introduced reporting biases. While the study identifies clear functional needs, a more systematic requirements engineering approach, such as formal goal-feature traceability or structured requirement taxonomies, was beyond its scope. Future work should expand on these aspects in collaboration with technical stakeholders.

Investigators mainly emphasized functional requirements. Their priorities centered on what the system should do, including data storage, retrieval, integration, and analytical support for tasks like hypothesis testing and evidence collection. Less attention was given to non-functional aspects such as usability, scalability, or long-term adaptability. This focus reflects the practical demands of investigative work but suggests that future design should balance functional needs with broader considerations to ensure sustainable, effective systems.

6.5. Future work

Future research should involve system developers and larger, more diverse samples. Quantitative and observational studies could better assess effectiveness. A more thorough requirements engineering perspective is needed to trace how user needs translate into system features and to understand why gaps persist. Finally, exploring AI integration in CMS warrants further study.

7. Conclusion

This study examined how CMSs support criminal investigations, outlining their purposes, workflows, and unmet needs. We found that CMSs serve two essential purposes: the collection and processing of information. Through our analysis, we propose a six-dimensional concurrent workflow and the prepare-explore framework for knowledge discoveries that provides an understanding of the role of CMSs in criminal investigations.

We find that action management, protocol building, real-time collaboration, and recording of decision rationale are essential CMS functions. As important are case database generation and knowledge discovery. However, analytical capabilities, particularly in text analysis, such as named entity recognition, linking, and entity enrichment, remain underdeveloped. For knowledge discoveries, we find functions for hypothesis testing, summarization, retrieval, and detection of contradiction and knowledge gaps as missing. Last, notification and transcription of briefings were also highlighted by interviewees as wanted.

Based on our findings, we propose a guiding principle for these core functions. Specialized tasks, such as object recognition, large dataset processing, named entity recognition, and visualizations, are better kept modular and connected through standard interfaces. In our opinion, such an approach keeps CMSs stable and accountable while remaining flexible enough to integrate new functions. To meet evolving needs, next-generation systems should combine a robust core with adaptable services, ensuring both consistency and innovation in investigative workflow.

Lastly, we recommend that the development of such systems be grounded in structured requirements engineering practices to ensure that user needs are systematically captured, traceable, and effectively translated into system capabilities.

CRediT authorship contribution statement

Mads Skipanes: Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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