DOI: https://doi.org/10.54477/LH.25192353.2026.1.pp.72-80

CRIMINAL ANALYSIS AS A TOOL FOR INCREASING THE EFFICIENCY OF PRE-TRIAL INVESTIGATION IN CASES OF SERIOUS CRIMES

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Recieved: 12 January
Accepted: 29 February

Abstract

This article examines the role of criminal analysis as a key instrument for enhancing the effectiveness of pre-trial investigations in cases involving serious crimes. It analyzes contemporary approaches to the application of criminal analytical methods and technologies in law enforcement practice, with particular emphasis on their significance for the systematization, interpretation, and forecasting of criminal activity. The author focuses on the methodological foundations of criminal analysis, which provide a comprehensive understanding of the criminogenic situation and facilitate the identification of key factors and relationships among actors involved in criminal activity. An updated methodological model of criminal analysis is proposed, integrating traditional analytical approaches with innovative information technologies, including big data analytics and machine learning methods. The scientific novelty of the study lies in the identification and systematization of key factors influencing the quality of operational and investigative activities, as well as in the development of practical recommendations aimed at optimizing criminal analytical work to improve the accuracy of crime forecasting and the efficiency of solving serious crimes. Particular attention is paid to issues of staffing and regulatory support, which hinder the effective integration of criminal analysis into pre-trial investigation processes. The findings of the study can be implemented in law enforcement practice to enhance the effectiveness of crime control and may also serve as a foundation for further academic research in the field of criminal analysis. The article also addresses the challenges associated with integrating criminal analysis into pre-trial investigations, including the shortage of qualified personnel and the need to implement modern information systems. The proposed recommendations are aimed at improving regulatory frameworks and enhancing the professional qualifications of analytical personnel. The results of the study may be of interest to researchers, law enforcement practitioners, and representatives of the judiciary.

Keywords: criminal analysis; pre-trial investigation; serious crimes; law enforcement; crime forecasting; big data; machine learning

1. Introduction

Enhancing the effectiveness of pre-trial investigations in cases involving serious crimes is an increasingly pressing issue for modern criminal justice systems. Serious crimes, characterized by their complex structure, high level of organization, and significant social consequences, require the application of advanced analytical approaches and technologies. In the context of the growing complexity of the criminogenic

environment and the emergence of new forms of crime, including transnational and cybercrime, traditional investigative methods are not always effective. This necessitates the integration of innovative tools to optimize pre-trial investigation processes, among which criminal analysis occupies a central position (Ratcliffe, 2016; Cope, 2004).

Criminal analysis functions as a comprehensive methodology that combines the systematization, interpretation, and forecasting of criminal activity in order to enhance investigative effectiveness. Through the application of criminal analysis, law enforcement agencies are better equipped to identify the structures of criminal organizations, uncover relationships between actors involved in criminal activity, and predict potential offenses, thereby improving the planning of operational and investigative measures (Boba Santos, 2013; Innes et al., 2005). However, despite its significant potential, the implementation of criminal analysis in pre-trial investigations faces several challenges, including deficiencies in the regulatory framework, a shortage of qualified analysts, technical limitations, and inadequate information systems (Perry et al., 2013).

The study of this issue is important from both theoretical and practical perspectives. Scholars and practitioners in criminal law and criminalistics, as well as law enforcement and judicial authorities, are interested in developing new methods that can improve the quality and speed of investigations, particularly in the face of contemporary crime challenges. At the same time, existing research tends to focus on specific aspects of criminal analysis, often overlooking the integration of traditional analytical methods with modern information technologies, particularly big data analytics and machine learning (McCue, 2015; Mohler et al., 2011).

This study is motivated by the need to provide a comprehensive examination of criminal analysis as a tool for enhancing the effectiveness of pre-trial investigations of serious crimes, taking into account current technological trends and challenges in law enforcement practice. The article aims to address existing gaps in the academic literature and to offer practical recommendations for improving regulatory frameworks and staffing in criminal analytical activities.

Historically, domestic criminal justice systems have primarily relied on criminalistics and operational-search activities as the main means of crime investigation. However, with the increasing complexity of the criminogenic situation, the growth in data volumes, and the emergence of new technologies, there has been a need for a more systematic approach criminal analysis which integrates various analytical methods to improve the quality of evidence and support the forecasting of criminal activity (Chamard, 2006). In practice, however, its application often remains fragmented due to limited resources, the absence of standardized methodologies, and insufficient regulatory support.

The theoretical foundation of this study is based on contemporary concepts of criminal analysis, which define it as a multi-component process of collecting, processing, and interpreting criminal information to provide a comprehensive understanding of the criminogenic situation. Previous research emphasizes that the integration of information technologies, including big data analytics and machine learning algorithms, opens new opportunities for improving the accuracy and speed of analytical outputs (McCue, 2015; Perry et al., 2013).

At the same time, several barriers to the development of criminal analysis in pre-trial investigations have been identified, including a lack of qualified analysts, the absence of unified standards, insufficient legal regulation of data processing and use for analytical purposes, and the technological limitations of information systems within certain law enforcement units (Innes et al., 2005).

The aim of this study is to provide a comprehensive analysis of criminal analysis as a tool for enhancing the effectiveness of pre-trial investigations in cases involving serious crimes, to identify the challenges associated with its implementation, and to develop practical recommendations for improving analytical activities within law enforcement

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agencies.

To achieve this aim, the following objectives are defined:

- To examine the theoretical foundations of criminal analysis in the context of pre-trial investigation;
- To analyze modern methods and technologies of criminal analysis, including innovative information solutions;
- To identify key challenges in integrating criminal analysis into pre-trial investigation practice;
- To develop recommendations for optimizing criminal analytical activities.

The research hypothesis is that the integration of criminal analysis using modern information technologies into pre-trial investigations significantly enhances the effectiveness of solving serious crimes, while also contributing to the optimization of operational-search activities and the forecasting of criminogenic trends. However, achieving these outcomes requires overcoming existing personnel, regulatory and technical barriers.

Thus, the results of this study may serve as a foundation for further academic research in the field of criminal analysis, as well as a practical tool for improving the quality and effectiveness of law enforcement activities in the investigation of serious crimes.

2. Theoretical foundations of criminal analysis in the context of pre-trial investigation of serious crimes

TIn contemporary law enforcement practice, criminal analysis serves as one of the key instruments for ensuring the effectiveness of pre-trial investigations, particularly in cases involving serious crimes. Its theoretical foundations are formed at the intersection of criminalistics, data analytics, operational-search activities, and information technologies, enabling the development of an integrated system for processing and interpreting criminogenic information. Criminal analysis is defined as a systematic process of collecting, processing, generalizing, and interpreting information about crimes, individuals involved, and the circumstances of criminal activity in order to support managerial and procedural decision-making (Ratcliffe, 2016). Its primary functions include informational-analytical, predictive, managerial, and coordination functions.

The informational-analytical function ensures the systematization of fragmented data; the predictive function enables the forecasting of crime trends; the managerial function supports informed decision-making during investigations; and the coordination function facilitates interaction among different law enforcement units (Boba Santos, 2013).

The methodology of criminal analysis is based on a comprehensive approach that combines both quantitative and qualitative research methods. Key approaches include the systemic, structural-functional, situational, and activity-based approaches. The systemic approach allows crime to be examined as a complex and dynamic system in which all elements are interconnected. The structural-functional approach focuses on identifying the roles and functions of individual elements of criminal activity. The situational approach emphasizes the specific conditions under which crimes are committed, while the activity-based approach concentrates on analyzing the behavior of individuals involved in criminal activity (Canter, 2004).

One of the core functions of criminal analysis is the systematization of criminogenic information obtained from various sources, including operational materials, databases, witness testimonies, and digital traces. Through the application of analytical methods, these data are integrated into a unified information model.

The interpretation of criminogenic information enables the identification of hidden relationships between events, the detection of patterns of criminal behavior, the

identification of key actors, and the determination of their roles within criminal activity. This is particularly important in the investigation of organized and serious crimes, where information is often fragmented (Innes et al., 2005).

Modern criminal analysis actively employs both traditional and innovative research methods. Their combination significantly enhances the effectiveness of analytical activities. Traditional methods include forensic analysis, content analysis, comparative analysis, link analysis, and spatio-temporal analysis (crime mapping). These methods make it possible to establish causal relationships, analyze the structure of criminal groups, and identify patterns of criminal activity (Chamard, 2006). Of particular importance is the use of analytical diagrams, which allow for the visualization of relationships among actors, events, and objects, thereby facilitating decision-making processes.

Innovative technologies, particularly big data analytics and machine learning, open new opportunities for criminal analysis. The use of classification, clustering, and forecasting algorithms enables the automation of pattern detection in large datasets (McCue, 2015). Machine learning methods are applied in crime prediction (predictive policing), the analysis of offenders' behavioral patterns, and the identification of risks of recidivism. At the same time, their application requires careful consideration of ethical and legal aspects, particularly data protection issues (Perry et al., 2013).

Effective criminal analysis requires the integration of traditional analytical approaches with modern information technologies. The proposed model is based on a multi-level structure that includes:

1. Data collection level – integration of information from various sources;
2. Processing level – application of traditional analytical methods;
3. Analytical level – use of machine learning algorithms;
4. Interpretation level – formulation of analytical conclusions;
5. Decision-making level – application of results in pre-trial investigations.

This model makes it possible to combine the depth of qualitative analysis with the speed and scalability of digital technologies, which is particularly important in cases involving serious crimes, where time and accuracy are of critical importance.

3. Criminal analysis as a tool for enhancing the effectiveness of operational and investigative activities

In the context of increasing complexity of the criminogenic environment and the growing number of serious crimes, criminal analysis has gained particular importance as a tool for enhancing the effectiveness of operational and investigative activities. Its application enables not only the systematization of large volumes of information but also the identification of hidden patterns, the establishment of links between actors involved in criminal activity, and the provision of evidence-based support for decision-making. Within the framework of intelligence-led policing, criminal analysis serves as a key component that ensures the efficient allocation of law enforcement resources and improves the overall effectiveness of crime control (Ratcliffe, 2016; Cope, 2004).

One of the central tasks of criminal analysis is the identification of key factors influencing criminal behavior, as well as the establishment of relationships among participants in criminal activity. In this context, methods of social network analysis are of particular importance, as they enable the examination of the structure of criminal networks, the identification of leaders, intermediaries, and peripheral actors (Innes et al., 2005).

Contemporary research indicates that the use of analytical tools for examining links between crimes makes it possible to effectively identify serial offenses based on similarities in modus operandi, thereby significantly increasing the clearance rate of complex criminal cases. Furthermore, the application of machine learning methods in combination with classical statistical approaches allows for the automation of such analyses, ensuring higher accuracy and speed of data processing (McCue, 2015; Mohler

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et al., 2011).

An important component of criminal analysis is also the identification of risk factors contributing to criminal activity, including socio-economic, spatial, and behavioral characteristics. The integration of these factors into analytical models makes it possible to develop a comprehensive understanding of the criminogenic situation and to forecast its development (Perry et al., 2013).

Criminal analysis significantly contributes to the optimization of evidence collection processes within operational and investigative activities. Through the use of analytical tools, law enforcement agencies are able to identify priority areas of investigation, concentrate resources on the most significant targets, and avoid duplication of efforts.

In particular, analytical products enable the identification of so-called crime "hot spots," which facilitates more effective planning of operational measures and resource allocation. Studies show that the application of spatio-temporal crime analysis significantly enhances the effectiveness of preventive measures and contributes to crime reduction in targeted areas (Chamard, 2006).

A significant direction in the development of criminal analysis is the use of artificial intelligence technologies for predicting criminal activity. Modern systems are capable of processing large volumes of data, including unstructured information such as texts, images, and digital traces, which allows for the detection of hidden patterns and the forecasting of potential crime scenarios. Such systems improve the accuracy of predictions and enable rapid responses to emerging threats. At the same time, it is important to consider that the effectiveness of forecasting largely depends on the quality of input data and the level of data processing. The presence of incomplete or biased data may distort analytical results, necessitating the implementation of quality control and data verification mechanisms (Perry et al., 2013).

The application of criminal analysis has a direct impact on improving both the speed and quality of pre-trial investigations. First, the use of analytical tools significantly reduces the time required for information processing and decision-making. The automation of analytical processes ensures the rapid identification of relevant data and the formulation of well-grounded conclusions.

Second, criminal analysis enhances the quality of investigations by enabling a deeper understanding of criminal processes and the establishment of causal relationships. Analytical products provide a comprehensive view of the situation, helping to avoid errors associated with fragmented information and improving the substantiation of procedural decisions (Boba Santos, 2013).

Research also demonstrates that the use of analytical data in law enforcement activities allows for more effective deployment of patrol units to high-crime areas, contributing to the reduction of crime rates and improving investigative outcomes (Ratcliffe, 2016). Moreover, the integration of criminal analysis into managerial decision-making processes ensures a more rational use of resources and enhances the effectiveness of operational and investigative measures.

At the same time, despite its considerable potential, the effectiveness of criminal analysis is constrained by several factors, including data quality, the level of training of analytical personnel, and organizational barriers. In particular, researchers note that analytical products require interpretation by police officers, which may introduce subjectivity into decision-making processes (Innes et al., 2005). This underscores the need to improve the professional training of analysts and to develop interdisciplinary competencies.

Thus, criminal analysis represents a powerful tool for enhancing the effectiveness of operational and investigative activities by enabling the identification of key crime factors, optimizing evidence collection, and improving the quality of pre-trial investigations. Its further development is associated with the integration of advanced information technologies, the refinement of methodological approaches, and the improvement of

professional training for specialists.

4. Challenges of integrating criminal analysis into pre-trial investigation and practical recommendations for its improvement

The integration of criminal analysis into the system of pre-trial investigation is a complex, multi-level process accompanied by a range of organizational, technological, кадрових → personnel-related, and regulatory challenges. Despite the significant potential of criminal analysis as a tool for enhancing the effectiveness of crime control, its full implementation in law enforcement practice often encounters both objective and subjective obstacles. At the same time, overcoming these challenges creates opportunities for the qualitative modernization of pre-trial investigations and the improvement of their overall effectiveness.

One of the key challenges is the insufficient level of regulatory and legal support for criminal analysis. In many legal systems, there is no clear definition of the status of a criminal analyst, their powers, or the procedures governing the use of analytical products in criminal proceedings. This creates legal uncertainty regarding the admissibility of analytical findings as evidence or auxiliary materials in the evidentiary process. In addition, restrictions related to the protection of personal data and confidential information complicate data exchange between different units and agencies.

Another significant challenge is the fragmentation of information systems and the lack of their proper integration. In law enforcement practice, multiple databases are often used that lack unified standards for structuring information and do not support automated data exchange. This leads to duplication of information, loss of its relevance, and a decrease in the effectiveness of analytical work. The absence of centralized analytical platforms limits the capacity for comprehensive analysis of the criminogenic situation.

An equally important issue is the insufficient level of personnel capacity. Criminal analysis requires highly qualified specialists who possess both expertise in criminalistics and operational-search activities, as well as skills in modern information technologies, including big data analytics and machine learning methods. However, many law enforcement agencies experience a shortage of such specialists, and the level of their training does not always meet contemporary requirements.

A separate group of challenges consists of organizational barriers, including the low level of interaction between analytical units and investigators, as well as an insufficient understanding of the role of criminal analysis among leadership. In some cases, analytical units perform only auxiliary functions and are not involved in strategic decision-making processes, which significantly reduces their effectiveness.

Another important issue concerns trust in the results of criminal analysis. The use of artificial intelligence and machine learning algorithms may raise concerns regarding the transparency and validity of the results obtained, particularly in cases where such algorithms operate as “black boxes.” This creates risks of misinterpretation of data and the adoption of unjustified decisions.

In order to overcome these challenges and enhance the effectiveness of integrating criminal analysis into pre-trial investigations, it is necessary to implement a set of measures aimed at improving regulatory, organizational, and technological components.

First, it is essential to improve the regulatory and legal framework governing criminal analysis. This includes the legislative recognition of the status of criminal analysts, the definition of their functions and powers, and the regulation of procedures for the use of analytical products in criminal proceedings. It is also important to develop clear standards for the collection, processing, and storage of information, taking into account data protection requirements.

Second, a key priority is the development of a unified integrated information and

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analytical system that ensures centralized access to data, automated processing, and the capacity for comprehensive analysis. Such a system should support the integration of various sources of information, including operational data, criminal records, digital traces, and open-source intelligence. The use of modern technologies, particularly cloud computing and artificial intelligence, would significantly enhance the efficiency of analytical activities.

An important aspect is also the improvement of professional training. It is necessary to introduce specialized educational programs for criminal analysts that combine theoretical knowledge with practical skills in the use of analytical tools. Regular training and professional development for law enforcement personnel are also essential for fostering analytical thinking and a deeper understanding of the capabilities of criminal analysis.

To overcome organizational barriers, it is necessary to ensure the integration of analytical units into managerial decision-making processes. This includes their active participation in planning operational-search measures, as well as the establishment of effective cooperation between analysts, investigators, and operational officers. A crucial role in this process is played by the development of a culture of data-driven decision-making within law enforcement agencies.

Special attention should be paid to ensuring the transparency and accountability of analytical processes. The use of explainable artificial intelligence (explainable AI) methods can increase trust in analytical results and ensure their proper interpretation. This is particularly important in the context of using analytical data in criminal proceedings.

Furthermore, the development of international cooperation in the field of criminal analysis is advisable, as it enables the exchange of best practices, the adoption of advanced methodologies, and improved information sharing between law enforcement agencies of different countries.

Thus, the effective integration of criminal analysis into pre-trial investigations requires a comprehensive approach that includes improving the regulatory framework, developing information infrastructure, enhancing professional training, and fostering a culture of analytical thinking. The implementation of these measures will contribute to improving the effectiveness of crime control, ensuring the soundness of procedural decisions, and strengthening the rule of law overall.

5. Conclusions

The conducted study has demonstrated that criminal analysis constitutes one of the key instruments for enhancing the effectiveness of pre-trial investigations in cases involving serious crimes. Its significance lies in ensuring a systematic approach to the processing of criminogenic information, which enables not only the generalization of large volumes of data but also the identification of hidden patterns, the establishment of causal relationships, and the formulation of well-founded managerial decisions.

It has been established that criminal analysis performs a number of essential functions, including informational-analytical, predictive, coordination, and managerial functions, which collectively contribute to improving the effectiveness of operational and investigative activities. The application of modern methodological approaches, such as systemic, situational, and activity-based approaches, makes it possible to consider crime as a complex social phenomenon and ensures a comprehensive examination of its manifestations.

The study confirms that the combination of traditional analytical methods with modern information technologies, particularly big data analytics and machine learning, significantly expands the capabilities of criminal analysis. Such integration contributes to increasing the accuracy of crime forecasting, optimizing the process of evidence collection, and reducing the time required for procedural decision-making.

It is substantiated that criminal analysis has a direct impact on improving both the speed and quality of pre-trial investigations. Its application enables more effective identification of key elements of criminal activity, the establishment of links between actors, the determination of priority areas of investigation, and the rational allocation of law enforcement resources.

At the same time, the study has identified a number of challenges that hinder the effective integration of criminal analysis into pre-trial investigation practice. These include insufficient regulatory and legal support, fragmentation of information systems, a shortage of qualified personnel, organizational barriers, and a lack of trust in analytical results. The existence of these issues necessitates a comprehensive approach to their resolution.

The proposed practical recommendations are aimed at improving criminal analysis through the development of a clear regulatory framework, the establishment of integrated information and analytical systems, the enhancement of professional training, and the strengthening of effective interaction among structural units of law enforcement agencies. Particular attention is paid to the implementation of modern technologies, including explainable artificial intelligence, which contributes to increasing the transparency and reliability of analytical decision-making.

Thus, criminal analysis is an essential component of the modern system of pre-trial investigation, ensuring increased effectiveness in combating crime, particularly in the area of serious criminal offenses. Prospects for further research include the development of innovative models of criminal analysis, the improvement of crime forecasting methods, and the adaptation of international experience to national law enforcement contexts.

References

Abrams, G. (2024). Artificial intelligence is revolutionizing criminal profiling and investigation. *Journal of Forensic Medicine,* 9, 355. https://doi.org/10.37421/2472-1026.2024.9.355

Boba Santos, R. (2013). *Crime analysis with crime mapping* (3rd ed.). Sage Publications.

Brown, E., & Ballucci, D. (2022). Understanding crime analyst's roles and responsibilities and the impact of their work. *Policing and Society*. https://doi.org/10.1177/17488958221095980

Canter, D. (2004). Offender profiling and investigative psychology. Journal of Investigative *Psychology and Offender Profiling, 1*(1), 1–15. https://doi.org/10.1002/jip.7

Chamard, S. (2006). The history of crime mapping and its use by American police departments. *Alaska Justice Forum, 23*(3), 1–9.

Cope, N. (2004). Intelligence led policing or policing led intelligence? *British Journal of Criminology, 44*(2), 188–203. DOI: https://doi.org/10.1093/bjc/44.2.188

Innes, M., Fielding, N., & Cope, N. (2005). The appliance of science? The theory and practice of crime intelligence analysis. *British Journal of Criminology, 45*(1), 39–57. DOI: https://doi.org/10.1093/bjc/azh053

Innes, M., Fielding, N., & Cope, N. (2005). The appliance of science? The theory and practice of crime intelligence analysis. *British Journal of Criminology, 45*(1), 39–57. https://doi.org/10.1093/bjc/azh053

Khalfa, R., & Hardyns, W. (2024). Led by intelligence: A scoping review on the experimental evaluation of intelligence-led policing. *Evaluation Review, 48*(5). https://doi.org/10.1177/0193841X231204588

Maoro, F., & Geierhos, M. (2025). Contestable AI for criminal intelligence analysis: Improving decision-making through semantic modeling and human oversight. *Frontiers in Artificial Intelligence, 8*. https://doi.org/10.3389/frai.2025.1602998

McCue, C. (2015). *Data mining and predictive analysis: Intelligence gathering and crime analysis* (2nd ed.). Butterworth-Heinemann.

Mohler, G. O., Short, M. B., Brantingham, P. J., Schoenberg, F. P., & Tita, G. E. (2011). Self-

DOI: https://doi.org/10.54477/LH.25192353.2026.1.pp.72-80

exciting point process modeling of crime. *Journal of the American Statistical Association, 106*(493), 100–108. DOI: https://doi.org/10.1198/jasa.2011.ap09546

Perry, W. L., McInnis, B., Price, C. C., Smith, S. C., & Hollywood, J. S. (2013). Predictive Policing. RAND Corporation. DOI: https://doi.org/10.7249/RR233

Perry, W. L., McInnis, B., Price, C. C., Smith, S. C., & Hollywood, J. S. (2013). *Predictive policing: The role of crime forecasting in law enforcement operations.* RAND Corporation. https://doi.org/10.7249/RR233

Piza, E. L., & Arietti, R. A. (2022). Crime analysis in policing. Oxford Research Encyclopedia of Criminology and Criminal Justice. https://doi.org/10.1093/acrefore/9780190264079.013.716

Ratcliffe, J. H. (2016). Intelligence-Led Policing (2nd ed.). Routledge. DOI: https://doi.org/10.4324/9781315721743

Ratcliffe, J. H. (2016). *Intelligence-led policing* (2nd ed.). Routledge.

Turet, J. G., & Seixas Costa, A. P. C. (2022). Hybrid methodology for analysis of structured and unstructured data to support decision-making in public security. *Data & Knowledge Engineering, 141*. https://doi.org/10.1016/j.datak.2022.102056