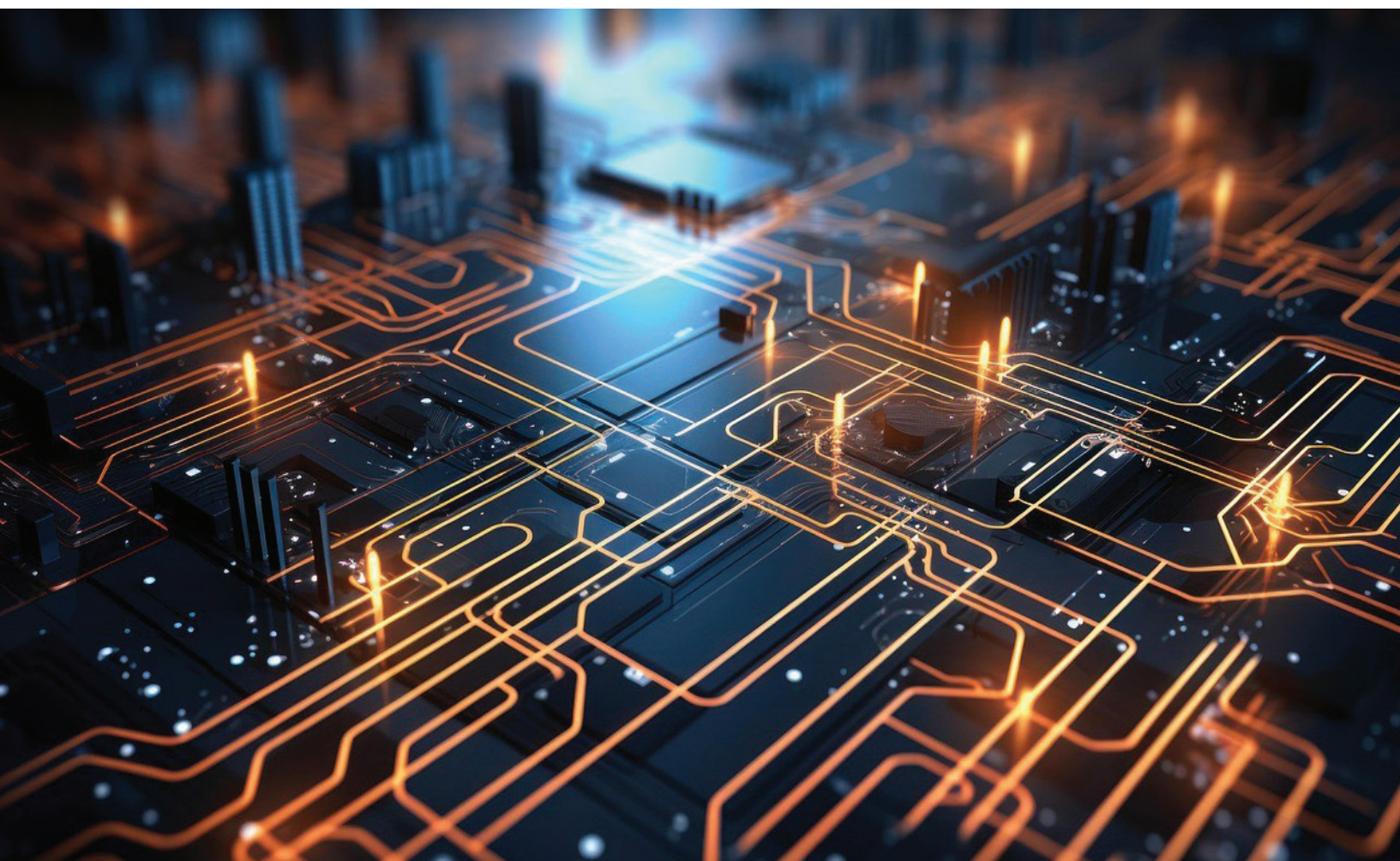




Netherlands Forensic Institute
Ministry of Justice and Security

Ready for the forensic questions of tomorrow

Strategic Knowledge and Innovation Agenda NFI
2025-2030



Foreword

Dear reader,

Before you lies the second Strategic Knowledge and Innovation Agenda (SKIA) of the NFI for the period 2025-2030. As a National Research Institute, the NFI faces the crucial task of developing, maintaining, and innovating forensic expertise to support forensic research of today and tomorrow. The agenda gives direction to our scientific focus and the NFI Strategic Forensic Research Program, responding to developments and needs in the criminal justice chain, and to increasingly rapid technological developments, particularly in the fields of digitalization, data-driven working, and artificial intelligence.

The NFI has a rich history of groundbreaking research, conducted in close collaboration with national and international partners. The associated knowledge transfer is central to our innovation strategy. The activities within the NFI Research Program align with the National Forensic Research Agenda and the forensic chain-SKIA (the joint knowledge and innovation agenda of the Public Prosecution Service, Police, and NFI).

With approximately forty forensic research areas, our knowledge base is unique. We strive not only to maintain this knowledge but also to further develop it with state-of-the-art methods. Our multidisciplinary approach, where different areas of knowledge collaborate, enables us to solve complex issues. Priority themes have been identified in this SKIA to this end.

This agenda brings structure and coherence to our research activities, while we continuously monitor new developments. Through our strong knowledge base, coupled with digital innovation, the NFI is ready for the forensic challenges of tomorrow!

I hope you will enjoy reading this report,



Dr. Annemieke de Vries
Director of Science and Technology
Netherlands Forensic Institute

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Introduction

The Netherlands Forensic Institute (NFI) makes essential contributions to fair justice and a safe society through reliable scientific, medical, and digital forensic research. As an internationally leading institute, the NFI works closely with partners both domestically and internationally.

Through continuous development of knowledge and innovation, driven by needs from the Justice and Security domain, the NFI guarantees the quality of forensic research. This agenda focuses on overarching themes that are developed in close collaboration with the forensic chain. The NFI distinguishes six forensic-scientific knowledge areas: biological, chemical, digital, physical, medical, and the interpretation of forensic data.

The agenda has been developed from a continuous exploration of needs within the criminal justice chain and strategic developments in the Justice and Security domain. This needs-based approach ensures that innovations directly contribute to the faster availability and higher reliability of forensic information.

To effectively respond to increasing digitalization and changing needs in the forensic field, among other things, the NFI employs a three-part research and development structure. This structure is based on a future-oriented analysis of developments in the field, with external needs being key.

The research activities are divided into three perspectives:

- Optimization of existing services and IT.
- Further development of emerging forensic techniques and methodologies.
- Exploration and development of innovative forensic solutions for future challenges.

This classification enables the NFI to both strengthen current services and anticipate future developments in the forensic research field. Concrete research projects are initiated and carried out for each of the perspectives.

This agenda will address specific developments per theme and how the NFI capitalizes these developments.

The process

For the creation of this SKIA, input was provided from various sources and perspectives. First, we used the SKIA 2019-2024 as a foundation for the new agenda. It provides a solid basis for our knowledge and innovation agenda for the coming years.

Naturally, for the SKIA 2025-2030, the broader forensic perspective has been included, so that this new NFI agenda is shaped in line with the Dutch Forensic Research Agenda (NFOA). The SKIA 2025- 2030 outlines the contribution from the NFI to the national themes of the NFOA.

Representing the forensic chain, the Steering Committee Chain Innovation has established two themes within the chain-SKIA that should guide the chain-wide development needs. We explicitly included these themes in the NFI SKIA 2025-2030.

To unite external and internal developments for the coming years in this new agenda, an NFI-wide survey was launched at the beginning of 2024 so that all colleagues had the opportunity to contribute to the content of this agenda. Shortly after, a session was organized in which a strong delegation of innovation-oriented employees from the various knowledge areas was tasked to further shape the new SKIA. After various internal feedback rounds, this eventually led to the determination of the NFI-wide themes and the themes for the various knowledge areas for the NFI SKIA 2025-2030.

Themes

The development theme 'Rapid and reliable' focuses on the optimization of, and remaining state-of-the-art in, the knowledge areas of the NFI.

In addition to this fundamental theme, the NFI focuses on the following four NFI-wide knowledge and innovation themes:

- From lab to location.
- Patterns and trends.
- Dynamics of traces.
- Artificial Intelligence (A.I.) and data science in forensic practice.

These themes are the NFI's translation of the nationally and chain-wide determined strategic development goals for the forensic research field.

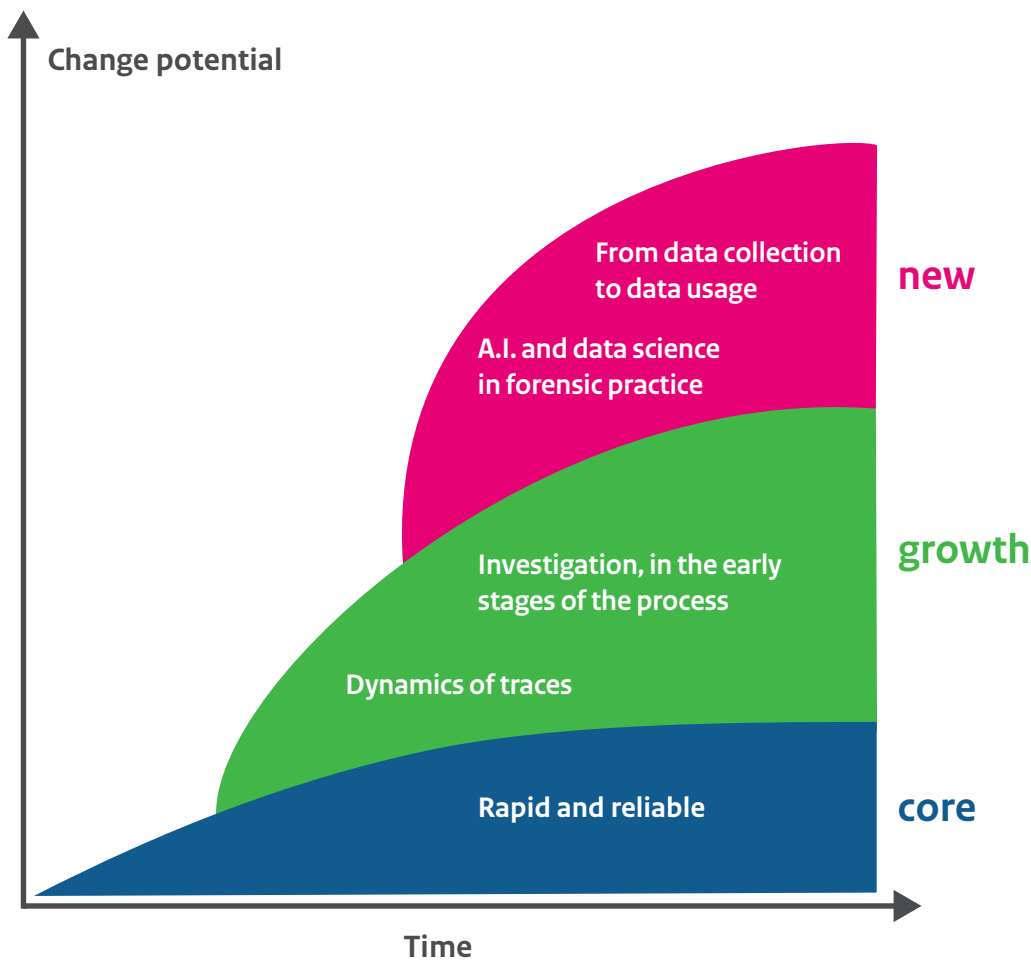


Figure 1. The strategic development themes within the horizons of the NFI Research Program

NFI-wide innovation and chain innovation

A number of knowledge and innovation challenges are of a multidisciplinary nature and hold importance for the broader forensic scientific field. As such, the NFI must deal with these challenges in an integral and multidisciplinary way. Or even chain-wide because of the strong coherence between the forensic chain contributors. This means that our innovation activities on these themes will be aimed at tackling these challenges in a collective and multidisciplinary way. In this way, we ensure that the outcome of these activities are broadly usable for the services of the NFI and can be deployed by our partners in the forensic chain.

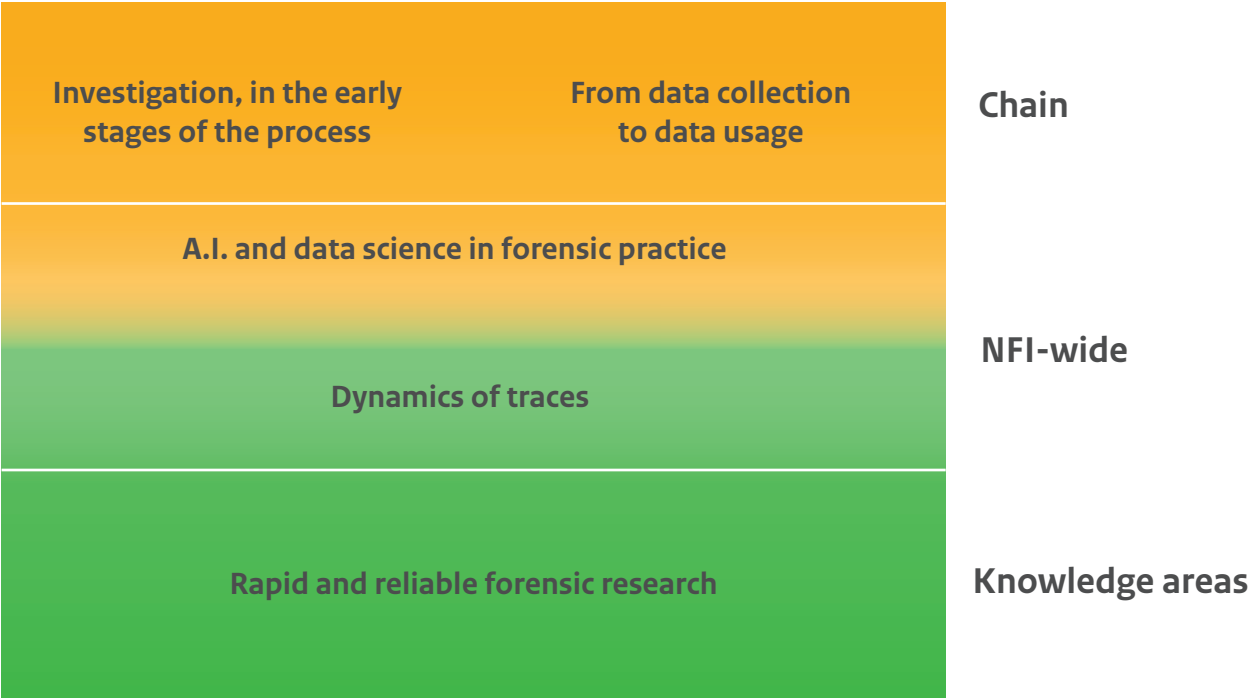


Figure 2. The strategic development themes within the strategic guidelines of the NFI Research Program

Investigation, in the early stages of the process - From lab to location

The early phase of the forensic process is both crucial and complex. Crucial because the quality of the research at the beginning of the process determines the quality of the rest of the process, and because early information can have a major impact on the effectiveness of the investigation process.

The work around a crime scene is also complex because many things come together. Knowledge, experience, technology, time pressure, legal frameworks. Only collaboration can optimize the outcome.

Around the crime scene, the forensic chain must be well-coordinated. There are also (scientific) questions related to the effectiveness of forensic research: finding the right traces (visualization, decision support) and discipline-specific development tasks around obtaining forensic information at the crime scene. Therefore, this is pre-eminently a cross-cutting development theme, relevant at all strategic levels.

With this theme, the NFI aligns with development goals in the forensic chain. By focusing on developments that make knowledge and technology deployable in an earlier stage, the NFI contributes to the development theme Innovation for early stage investigation in the forensic chain SKIA. The relevance of these developments for the Dutch forensic field as a whole can be seen in the overlap between ‘From lab to location’ and the NFOA theme ‘Everyone, everywhere, everything, always’.

From data collection to data use - patterns and trends

Forensic research provides significant added value in the investigation process and criminal prosecution. This research is generally speaking reactive and within the framework of one case. For a greater added value of forensic research, it is important to be able to use forensic information from multiple cases, and from multiple forensic disciplines, to make investigation and prosecution even smarter and therefore more effective.

There is a clear development from the $n=1$ approach of forensic research to the added value of case-transcending research. In short, the aim is to find patterns and trends that will help with operational decisions throughout the entire criminal process, from crime scene to court.

This theme is strongly driven by societal developments such as organized (subversive) crime and the far-reaching digitalization of both research material and research methods. For creating significant added value in practice, close collaboration with various parties in the broader criminal justice and security chain is needed. Therefore, it is essential that the development of new knowledge and techniques aligns well with the theme 'From data collection to data use' in the chain SKIA. Nationally, this urgency is expressed in, among others, the NFOA theme 'More with forensic information'.

A.I. en data science in forensic practice

The (socially and scientifically) responsible and effective application of data science in forensic research is a major challenge, especially when it comes to applying A.I. The investments in knowledge, availability of data, explainability, validation, and legal/ethical frameworks will be substantial, and this therefore requires an integral NFI-wide approach in close collaboration with external parties. For the NFI, the development challenge can be found in the application of data science and A.I.

in the 'analogue' forensic areas. Here the focus will mainly be on the copilot concept, in which the yet to be developed knowledge and techniques will be used to support the professionals and experts.

With the help of data science and A.I., we can make our processes smarter and faster to achieve better results from our research, which can also help the other forensic chain partners.

This development theme is the NFI's implementation of the NFOA theme with the same title.

The dynamics of traces

The dynamics of traces concerns the 'behaviour' of forensic traces - how they originate, move, change, or disappear during and after an incident. This includes the transference, persistence, and prevalence of traces under different circumstances.

With the increased sensitivity of research methods, increasingly smaller traces can be detected and analysed. This brings new challenges for interpreting the meaning of these traces. The presence of a trace does not directly indicate how it got there.

Knowledge about the dynamics of traces is essential for all forensic disciplines, from DNA research to digital forensic research. This knowledge is not only crucial for correctly interpreting traces in the context of a criminal case but also for the development of better methods for finding, securing, and analysing traces. Therefore, it is important that the NFI continues to invest in research into the dynamics of traces in all these different knowledge areas.

With this development theme, the NFI also contributes to the NFOA themes 'The ultimate forensic reconstruction and Finding, securing, and following traces'.

Reliable and fast

The core of the NFI's work is to conduct Rapid and reliable research on forensic traces. The NFI can only provide added value with its research for investigation and legal proceedings if this can be carried out in a timely manner and reliability remains guaranteed as a solid basis.

From its various fields of expertise, the NFI constantly works on improving methods that lead to faster and more reliable results. This makes the theme an important part of the NFI's ongoing development efforts. The knowledge areas of the NFI are medical, biological, digital, biometric, physical, chemical and the interpretation of forensic data. To give more specific content to this theme, the NFI developed a knowledge and research agenda for each of these knowledge areas, which is explained further in this document.

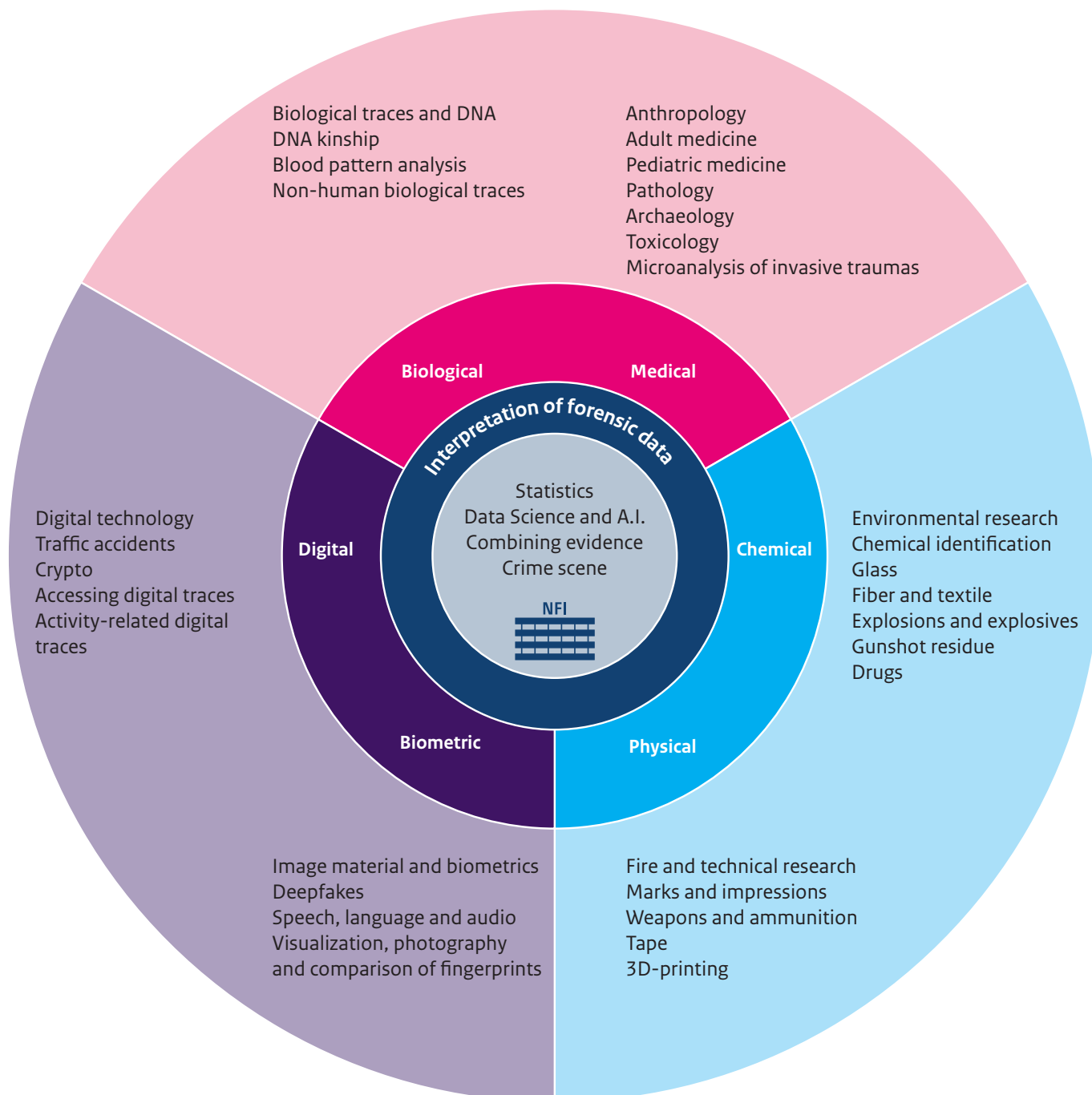


Figure 3. The different knowledge areas of NFI

Chemical and Physical

Chemical and physical forensic research entails various areas of expertise. Method development and the subsequent implementation for visualizing, analysing, and interpreting traces strengthens the added value of these areas for the forensic chain, both within and between cases. Therefore, within these disciplines, we jointly focus on the following four themes.

Profiling chemical and physical traces to visualize patterns and trends

We focus on the construction and use of databases of physical and chemical traces to (automatically) visualize trends and links between traces, (crime) scenes, spaces, persons, production processes, and distribution networks.

We focus on developing and implementing new methods, A.I. systems, and image comparison methods, to achieve a broader, faster, and more in-depth analysis of traces and thereby provide a complete overview of information.

In this way, we contribute to the effective connection and combination of relevant data within the forensic chain.

Objective interpretation at source and activity level

We focus on objectifying and developing research at source level and activity level.

We do this by building the necessary data(bases), knowledge and analysis models, strengthening expert judgments through validation, calibration, and minimizing influence, and by effectively combining information from the systems and expert judgments. By focusing on automation, we can analyse and interpret more traces, further ensuring the robustness of the research.

Through insight into, among other things, the dynamics of traces, we contribute to reconstructions.

Visualizing and analysing optical and chemical traces

We focus on combining information through image analysis for more effective and robust multidisciplinary trace research at the object of evidence level (macroscopic). We do this by developing and implementing a hybrid human/A.I. scan system for locating and classifying clusters of chemical and physical traces and multidisciplinary traces such as body fluids. We focus on the development and improvement of multimodal imaging techniques and (semi-)automatic image analyses per type of trace and characteristic of an object of evidence (microscopic).

By linking the location data of the microscopic and macroscopic analysis results to the crime scene, we achieve a complete visualization of spatial relationships. This contributes to the interpretation of the trace pattern in relation to disputed actions (activity level).

Development of mobile techniques, from lab to location

We focus on the development of methods and implementation of mobile (remote or otherwise) techniques at the crime scene. This is to collect, share, and interpret faster, more, and different types of data and to work as effectively as possible as a forensic chain. We also focus on the development of markers and tracers for the investigation.



Medical

The development of medical forensic research within the NFI focuses on case-related questions to bring focus, and is aligned with the knowledge agenda 2025-2030 of the Forensic Medical Society. The NFI will focus on five themes within this discipline in the coming years.

Time

Investigating chronologies is one of the most important forensic medical issues. When did an injury occur? How long has a deceased person been dead? What effect does time have on diagnostics and traces? Answers to these questions are based on the interdependencies between the course of time and a specific biological and chemical process. For example, the phase of decomposition can say something about the postmortem interval, and injuries can be dated based on the healing phase. Due to the limited knowledge about the variation in these biological processes, it is often not yet possible to make accurate and reliable statements about chronologies. The NFI is committed to gathering knowledge and developing innovative techniques to work towards a more accurate answer to the above questions.

Diagnostics

The NFI is committed to developing and applying new techniques so that medical diagnostics are improved and renewed. Through a more sensitive and broader use of the latest analytical techniques, for example, more relevant foreign substances and their potential effects can be determined. Insight into the health condition of the deceased at the time of death can also be improved through research with new biomarkers or research in alternative matrices.

Data Science and A.I.

By structurally storing, generating and combining knowledge, complex issues, relations and trends can be investigated. By unlocking and analysing different types and large amounts of data (text, images, and videos) and deploying artificial intelligence, new diagnostic applications can also be developed, and case research can be supported. For example, the development and training of a model to recognize bone fractures in X-ray images. By automating work processes the efficiency of case research and its quality control can be improved.

Visualization

The NFI focuses on the integration of imaging techniques such as radiology in order to make forensic-medical/ anthropological research easier, faster, and less invasive. In addition, the use of (archive) images offers the possibility for validation of traditional, and development of new, forensic-medical/ anthropological methods. By using alternative sensors, relevant traces both inside and outside can be mapped. Finally, chemical imaging techniques offer possibilities for spatially detecting substances at a certain location, such as the distribution over hair and nails or in an organ section.

Forensic chain support

At a crime scene, it is important to quickly receive the right information. With innovative investigation methods in the field or at the crime scene, traces can be found and/or interpreted (faster). This can be done, on the one hand, by developing mobile techniques or better detection methods and on the other hand by faster investigation and by making results available sooner. To find the right traces, it is important to conduct structured and substantiated crime scene investigation, with an eye for different scenarios. For robust and traceable research at the crime scene, it is important to focus on adjustments in the process that can support crime scene investigators in their decision-making. The NFI focuses on more intensive and smarter collaboration throughout the entire forensic chain, for the benefit of a safer society.



Biological

Biological forensic research includes, among other things, research into human DNA, but also non-human DNA, ecology, phylogeny, morphology, and population dynamics. Within this discipline, the NFI will focus on the following five themes in the coming years.

Investigation-oriented DNA information (also for intelligence purposes)

Even if a DNA profile does not match in the DNA database, the NFI wants to be able to provide investigative information. The NFI therefore focuses on DNA genealogy research, the possibilities that genealogical databases offer, and on externally observable characteristics, biogeographic origin, and chronological age for which information is contained in someone's DNA. In addition, data analysis is used to find connections between cases for intelligence purposes.

Fit-for-purpose interpretation and reporting of complex biological/DNA traces

With minimal amounts of DNA material and/or many donors in one trace, interpretation is difficult. The NFI develops tools and interpretation software (such as DNAXs) to make robust statements. These models and software are also being made suitable for MPS data. With new DNA technology, the NFI can extract more information from micro-organisms, which are always abundantly present, and thus improve the geographical origin determination of the trace material. To answer questions at the activity level, trace images are analysed, and research is conducted to gain knowledge about the chance of finding traces related to different scenarios.

New insights through multidisciplinary collaboration

By better collaboration within the NFI, it becomes possible to combine different traces, insights, and interpretations from different disciplines. This creates new ideas that add value in forensic case research.

Utilizing new technical possibilities and innovations

Massively Parallel Sequencing (MPS) is a DNA technology that has undergone enormous development in the last decade and is applied for various applications in cases. The developments continue (e.g., direct and adaptive sequencing). The NFI investigates the forensic applications of these variants and develops necessary bioinformatics tools, so that they can also be applied in practice.

Efficient and effective data-driven research

The ability to link various types of data and traces leads to better data-driven research. In this way, connections and relationships can be found across cases that can provide intelligence information. Or lessons can be learned from the decisions made regarding choices in the approach to case research, especially with complex profiles. The development is driven by automation, digitalization, agile databases, and the need to link different types of traces.



Digital

Digital forensic research takes place in a rapidly changing playing field, with new devices, apps, and software continuously appearing on the market. To be able to prioritize R&D, the NFI focuses on reusability and major case impact. Division-of-work and automation are important means to continue to unlock the rapidly changing digital sources. The NFI will work on the following six themes within this discipline in the coming years.

Explainability of digital forensic research and results

Methods and techniques used in the digital forensic field (technical, legal, tactical) are very broad, not illustrative, sometimes long but often only usable for a short time. The explainability of this digital research can therefore be very difficult. The NFI investigates how such methods and techniques can be validated in a robust yet flexible way, so that their use is controllable and well-explainable.

Authenticity and integrity of digital evidence

There are various methods and techniques that affect the integrity of digital data, e.g., anti-forensic software and deepfake technology. The NFI investigates how the use of these methods and techniques can be determined and how the products of these methods and techniques can be distinguished from authentic material.

Visualization of digital evidence

Visualization of large data collections provides new insights. The NFI investigates how the growing amount of data can be made accessible for forensic research and how deviations from the normal pattern (pattern-of-life) can be detected.

Reference data

For the mentioned research, there is a need for digital forensic reference data. However, this is difficult to obtain within the digital forensic domain and must be kept continuously up to date because the data is often device- and app-specific. The NFI researches and develops methods and techniques for the uniform recording and sharing of the interpretation of heterogeneous data, for automatically periodically recording such data and for automatically recognizing changes within the data. In addition, the NFI investigates the forensic implications of this change for forensic research.

Access to digital traces

Devices and their data are increasingly well-secured and encrypted. The NFI focuses on the (further) development of methods and techniques for forensic acquisition of cryptographically secured information from hardware and data stored on data carriers. For hardware for example: failure analysis, repair of electronic equipment and chips, reverse engineering, software exploitation, side channel analysis, and fault injection.

Relevant for information on data carriers are: cryptanalysis of software and communication protocols, password recovery, recognition and processing of source files with passwords, and techniques for automatic expansion of password lists. In addition, the NFI investigates the detection of steganography and the extraction of information hidden with this method.

Interpretation of digital evidence

The NFI conducts research into the meaning and evidential value of various types of digital traces. For questions at the activity level, the relation between traces in the digital world and actions in the physical world is investigated. The NFI focuses on the uniform description and recording of human actions with digital devices and a uniform representation of digital evidence.



Interpretation of forensic data

In every forensic investigation, data is collected, interpreted, and processed into conclusions. Uncertainty plays an important role in this. The possible influence of the observer is also relevant.

Innovation in methods, techniques, and reasoning methods are important to deal with these uncertainties and to reach a well-founded and clear conclusion of the investigation. Case-transcending data, data from different types of traces, and data about the dynamics of traces play an increasingly important role.

Within this knowledge area, the NFI will therefore focus on the following three themes in the coming years.

Artificial Intelligence (A.I.)

A.I. continues to undergo rapid development (see NFI-wide A.I. theme). This creates many new possibilities for interpreting forensic data, but also for improving the readability of NFI reports.

Communication of forensic information

Forensic reports and conclusions are complex matter, while proper understanding and use are crucial. Projects that improve readability lead to important improvements in the use and understanding of NFI reports. There is a strong need for means to clearly communicate complex subjects, such as conclusions from Bayesian networks. The communication form does not necessarily have to be a report; the development of info sheets, videos, infographics, or text boxes can also be considered.

Interpreting data and numerical evaluation

A crucial aspect in many NFI reports is the interpretation and evaluation of forensic research results in the context of a specific case, and increasingly often across multiple cases. Relevant hypotheses are formulated.

Then it is determined how likely it is to find the research results, assuming the hypothesis is true. This is particularly

challenging in complex interdisciplinary cases, which often involve combinations of different types of traces.

This calls for the development of broadly applicable numerical methods or graphical/visualization methods.

Continuous investment must also be made in reliable numerical evidential value and the data needed.

Validation and sensible use of the methods are essential, for transparent reasoning and the numerical expression of the evidential value of the research results.



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