# Best Practice Manual for the Forensic Handwriting Examination

## ENFSI-BPM-FHX-01

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# BEST PRACTICE MANUAL FOR THE FORENSIC HANDWRITING EXAMINATION

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# 1. AIMS

This Best Practice Manual (BPM) aims to provide a framework of procedures, quality principles, training processes and approaches to the forensic examination of handwriting. This BPM can be used by Member laboratories of ENFSI and other forensic science laboratories to establish and maintain working practices in the field of forensic handwriting examination that will deliver reliable results, maximize the quality of the information obtained and produce robust evidence. The use of consistent methodology and the production of more comparable results will facilitate interchange of data between laboratories.

The term BPM is used to reflect the scientifically accepted practices at the time of creating. Despite its implicit suggestion that alternative, equivalent Practice Manuals are excluded at beforehand, in this series of ENFSI Practice Manuals the term BPM has been maintained for reasons of continuity and recognition.

# 2. SCOPE

This BPM is aimed at experts in the field and assumes prior knowledge in the discipline. It is not a standard operating procedure and addresses the requirements of the judicial systems in general terms only.

Due to the fact that the terms “forensic handwriting examination” and “graphology” (or “Judicial Graphology” or “Forensic Graphology”) are frequently confused and given (wrongly attributed) equivalence, sometimes even within judiciary, it is to be stressed that there is a clear difference between them. While they both focus on handwriting (including signatures) and the process of writing, the questions they answer and the methods they use are entirely different.

Forensic handwriting examination, just as many other forensic disciplines, aims for identification of a person based upon a trace they leave. Just as in forensic DNA or fingerprint analysis the identification derives from uniqueness of the genome or the pattern of ridges on a skin, forensic handwriting examination deals with a trace that exhibits individual neuromuscular behaviour of a person. This discipline does not make any assumptions about the relationship between handwriting characteristics and personality because the analysis of personal traits has no relevance to writer identification.

Graphology on the other hand, includes inferring character traits or intelligence of the person from interpreting the handwriting characteristics.

It is not the task of a forensic handwriting examiner to deal with the validity of a graphological diagnosis, and possible explanations, and it is not the role of a graphologist to form opinions on the authorship of handwriting. Therefore, ENFHEX does not support the use of this Best Practice Manual, in full or part, to validate the role of a graphologist within the forensic environment.

Documents, of various types, are routinely encountered in casework and are required to be examined for a number of reasons (see Appendix 1 – Key Knowledge Requirements for Forensic Handwriting Examination). The examination of these

documents may reveal information which is invaluable to the investigation of a crime, or which may provide evidence which indicates that a crime has been committed.

This guidance document covers the process from the receipt of the test items into the "handwriting laboratory" to the presentation of evidence in the courts. As such it encompasses the systems, the procedures, the personnel, the equipment and the facilities and environmental conditions required for forensic handwriting examination.

The law enforcement framework and the legal systems within which a forensic laboratory is working will determine the degree of direct control that individual practitioners have over each stage of a process. Where the practitioner is not directly involved in any particular stage they should still be in possession of sufficient knowledge to ensure the maintenance of good scientific practice.

# 3. DEFINITIONS AND TERMS

For the purposes of this Best Practice Manual (BPM), the relevant terms and definitions given in ENFSI documents, the ILAC G19 "Modules in Forensic Science Process", as in standards like ISO 9000, ISO 17000, ISO 17020 and ISO 17025 apply. In this section only the field specific terms and definitions, which assist in the interpretation of this BPM, are listed.

Forensic Handwriting Examiner - An individual that undertakes a Forensic Handwriting Examination. This includes both Reporting Scientists and Analysts/Assistants.

Forensic Handwriting Examination - The scientific examination and comparison of handwritten documents to determine whether or not two or more pieces of handwriting have been completed by one individual. This includes authentication of one or more questioned (Qn) signatures by comparison with a set of known (Kn) signatures.

# 4. RESOURCES

## 4.1 Personnel

People are likely to be the most important resource in any forensic application and in order to allow staff to work effectively and efficiently everybody concerned in the process must understand the nature of the tasks and the human qualities required to perform them. It is accepted that individual organisations will recruit Forensic Handwriting Examiners in accordance with the requirements of that organisation (and this may include legal considerations as well as academic qualifications or work experiences). As such it is acknowledged that Forensic Handwriting Examiners will have a wide variety of experience, training and background knowledge. All of these can be obtained through a range of different processes, but should include the criteria detailed in Appendix 1 - "Key Knowledge Requirements for Forensic Handwriting Examination".

### 4.1.1 Roles and responsibilities

The key roles for forensic handwriting examinations are:

- Reporting Scientist – The forensic scientist responsible in a particular case for directing the examination of the items submitted, interpreting the

findings, writing the report and providing evidence of fact, and opinion, for the court.

- Analyst/Assistant – An individual carrying out general casework examinations or analytical tests under the supervision of a Reporting Scientist and who is able to provide information to assist with the interpretation of the tests.

Both of these roles can be carried out by the same individual.

4.1.2 Competence requirements

The qualifications, competences and experience that individuals require to carry out the various aspects of forensic handwriting examination will depend on the intellectual and practical demands of the various aspects of the work. Appendix 1 – "Key Knowledge Requirements for Forensic Handwriting Examination" details the general levels of knowledge required for individuals to undertake the particular aspects of work, whilst Appendix 2 - "Training Requirements for Forensic Handwriting Examiners" details the training requirements and the assessments that will be applied.

The following experience and areas of competence would be expected as the minimum standard for the key roles defined above, in forensic handwriting examination:

- Reporting Scientist - Knowledge of the theories, analytical techniques and procedures applicable to forensic handwriting examination; competence in the evaluation and interpretation of findings in handwriting cases; knowledge and experience of the requirements and procedures of the criminal justice system for the presentation of evidence, both written and oral

- Analyst/Assistant - Knowledge of the theories, analytical techniques and procedures applicable to forensic handwriting examination; the practical skills to operate specialist equipment and to carry out forensic handwriting analysis safely and reliably in compliance with laboratory protocols; an understanding of the requirements of the criminal justice system

4.1.3 Training and Assessment

The levels of training and assessment are dependent on the role being undertaken; however the following must be addressed in developing a training and assessment programme:

- laboratories should have written standards of competence for each role, a documented training programme and processes for assessing that trainees have achieved the level of competence required;

- all training should be completed within the specified time frame and the outcome of assessments documented on the individual's training records;

- the assessment of competence can be accomplished through a combination of appropriate means, including:
  - practical tests
  - written and/or oral examinations
  - role exercises (for example "mock" courts)
  - casework conducted under close supervision
  - a portfolio of previous work

A trainee should only be recognised as competent when he or she has been assessed as meeting the defined standards of performance and only then be permitted to undertake independent casework in the relevant area. A record of the assessment date and result of the assessment should be added to the relevant training record. All personnel involved in the field of forensic handwriting examination will also be required to demonstrate that they have maintained their competence at regular intervals (for example with the use of collaborative exercises or proficiency tests).

4.2 Equipment

4.2.1 The principle equipment required for forensic handwriting examination is a suitable form of magnification (such as a stereo-zoom microscope).

4.2.2 Other instrumentation (see Appendix 3 section 7), often falling within the remit of forensic document examination, may assist the Forensic Handwriting Examiner. This is not covered within this documentation.

4.2.3 Only appropriate and properly operating equipment should be employed in casework, and then only within the limits of the performance checks carried out.

4.3 Reference materials

No specific requirements

4.4 Facilities and environmental conditions

The principle considerations for forensic handwriting examination are the need for sufficient, secure workspace to allow for efficient and effective working and the need for good quality lighting, preferably natural daylight.

When necessary correct anti-contamination procedures must be used to prevent cross-contamination.

4.5 Materials and Reagents

No specific requirements

# 5. METHODS

5.1 Anti-Contamination Procedures

All items submitted for forensic handwriting examinations should first be examined for the integrity of their packaging. Any deficiency in the packaging, which may compromise the value of a laboratory examination, should be noted, and the customer

informed. Such a deficiency may be grounds for refusal to carry out the laboratory examination.

Where applicable staff should wear suitable protective clothing to minimise the risk of accidentally leaving trace evidence, such as fingerprints or DNA, on the items being examined.

### 5.2 Examination Techniques and Methods

Whilst it is accepted that individual organisations will have their own, accredited methods, the principle of each method should be carried out in accordance with the recommendations in the appendices to this Manual (Appendix 3 - “Overview Procedure for Forensic Handwriting Examinations and Comparisons”).

### 5.3 Analysis Protocols

The actual work that is carried out in individual cases should be determined by the requirements of the case and will depend on the value of any other evidence which may be available. But a systematic approach should always be adopted, to ensure consistency of delivery of services that are fit for purpose.

Whatever work is done, the Forensic Handwriting Examiner should always use the combination of techniques available that offers the greatest potential for recovering any forensically viable information, taking into account the nature of the work to be undertaken.

The choice of the most suitable methods of examination can only be made at the time of the initial assessment by the Forensic Handwriting Examiner involved. Given the same case circumstances, all laboratories would ideally adopt the same analysis protocol, but in practice the extent to which such harmonisation can be achieved will be limited. This protocol can thus act only as a guide.

Non-destructive tests should be given priority.

### 5.4 Case Records

The exact requirements for recording casework information will depend on the legal system of the country/state of jurisdiction. As a minimum, however, the records should be in sufficient detail to allow another Forensic Handwriting Examiner, competent in the same area of expertise, to identify what has been done and to verify the findings.

For casework involving the forensic handwriting examination, the records should include details of:

- the items that were submitted to the laboratory, the information accompanying the items on submission and the nature of the work requested
- the method of submission (e.g. by hand, by post, etc.), by whom and on what date(s)
- all movement of casework material within the laboratory system, the person(s) responsible for the movement and the date(s) the movements took place
- the method of return of items to the submitting organisation (e.g. by hand, by post, etc.), by whom and on what date(s)

- any changes, or additions to the items
- all communications within the laboratory and between the laboratory and the submitting organisation about the case
- for each item examined, the labelling, method of packaging and integrity of packaging on receipt
- what examinations have been carried out, when, in what order, where and by whom
- all observations made, photographs taken and analytical data generated
- the specific examination methods and procedures used
- all draft and final reports or statements generated
- administrative and technical review, when and by whom

Wherever possible, written records should be made on standardised forms, examples of which are shown in the relevant appendices.

## 5.5 Peer Review

It is important within forensic handwriting examinations that the results of any examinations undergo Peer Review. The Peer Review will cover, as a minimum, the Critical Findings in the case. The Peer Review should also cover the Technical Findings.

### 5.5.1 Critical Findings

Whilst the exact legal requirements may be different for different organisations, in general findings of critical evidential value should be confirmed by a second Reporting Scientist who has been authorised and is competent to carry out such checking procedures. Findings are considered critical when:

- they make a significant contribution to the findings in the case, and
- are incapable of being confirmed at a later time, or are subject to possible differences in interpretation by different Reporting Scientists.

A record of these checking procedures should be made within the case notes, bearing the signatures (handwritten or electronic) of both the Reporting Scientist and the reviewer.

Where critical findings have not been reviewed, the submitting body should be informed that the results are preliminary.

### 5.5.2 Technical Findings

The technical findings are the results of the examination(s). These findings must be justified and supported by documentation within the casefile. Areas that should be covered by the technical review include:

- is there adequate documentation for all the materials examined
- have the appropriate examinations/analyses been carried out
- have the relevant Quality Assurance (QA) procedures been followed
- have analytical identifications/comparisons been checked
- is the statement/report accurate and does it refer to all items submitted

# 6. VALIDATION AND ESTIMATION OF UNCERTAINTY

## 6.1 Validation

The laboratory should, where possible, only use validated techniques and procedures for the forensic handwriting examination and the interpretation of their significance in the context of the case.

6.1.1 Validation requires as a minimum that:

- there is an agreed requirement for the technique or procedure;
- the critical aspects of the technique or procedure have been identified and the limitations defined;
- the methods, materials and equipment used have been demonstrated to be fit for purpose in meeting the requirement;
- there are appropriate quality control and quality assurance procedures in place for monitoring performance;
- the technique or procedure is fully documented;
- the results obtained are reliable and reproducible;
- the technique or procedure has been subjected to independent assessment and, where novel, peer review;
- the individuals using the technique or procedure have demonstrated that they have been trained and have demonstrated that they are competent.

6.1.2 Where the techniques or procedures have been validated elsewhere, the laboratory is required to carry out a verification exercise to demonstrate that it can achieve the same quality of results in its own environment.

## 6.2 Estimation of uncertainty of measurement

Whilst it can be accepted that within forensic handwriting comparisons Forensic Handwriting Examiners do not routinely make the sort of measurements described in paragraph 5.4.6 of ISO 17025, the standard indicates that:

- any laboratory should at least attempt to identify all the components of uncertainty and make a reasonable estimation of the uncertainty
- and that any reasonable estimation should be based on knowledge of the performance of the method. This should make use of, for example, previous experience and validation data.

As such it is necessary to demonstrate that the issue of "uncertainty components" is addressed. Consideration should be given to each of these components when the Forensic Handwriting Examiner is assessing the material as part of their examination, including:

6.2.1 Sample size - The results (and strength of the results) of any handwriting and signature examinations may depend on the amount of material submitted for comparison. The results also depend on other criteria such as the complexity of the handwriting and the stylisation of the signature.

6.2.2 Quality of material examined - The quality of the submitted material will have an intrinsic effect on any examination. The following list indicates a number of instances where this will occur:

- Handwriting that has been submitted as photocopies, photographs or scans does not possess all of the detail present in original handwriting
- Inks that have been treated with a solvent are more difficult to differentiate than un-treated inks
- Non-standard writing tools and/or surfaces (such as sprays, paint and outdoor surfaces)

6.2.3 Complexity of handwriting/signatures - Handwriting and signature examinations and comparisons, and the results of those examinations and comparisons, depend significantly on the relative complexity or stylisation of the handwriting or signatures.

6.2.4 Human error - There are a number of circumstances where human error can be critical. To counter these, consideration should be taken to address each of the potential areas, for example:

- Training - all examiners undergo a formal, scheduled and detailed, training programme, during which their progress is monitored and assessed. Where errors or misidentifications are made, the trainee is made aware of those misidentifications or errors, and any corrective actions undertaken.
- Competency - the competency of each practitioner is routinely checked and monitored against a set of specified criteria.
- Procedures - standard operating procedures are in place to ensure a uniformity and conformity of approach to each examination. These procedures are used during the training programme, and the work of the trainee and other members of staff are periodically reviewed against these procedures.
- Repeat analysis - examinations are carried out independently by a second practitioner. The results of both practitioners are subsequently discussed, and a consensus result reached (this is usually, but not exclusively, in agreement with the more cautious set of results). Occasionally, where the examination may be more complicated or result in more contentious findings, the material is given to a third practitioner for their opinion.
- Collaborative Exercises/Proficiency Testing (CE/PT) - the ability of each examiner is tested regularly, over the range of examinations undertaken, using external CE/PTs. The reported results are assessed against the "known" answers, and any areas of disagreement are discussed and any corrective actions undertaken.

# 7. QUALITY ASSURANCE

Proficiency tests should be used to test and assure the quality of Forensic Handwriting Examinations. A list of currently available CE/PT schemes as put together by the Quality and Competence Committee (QCC) is available on the ENFSI website. “Guidance on the conduct of proficiency tests and collaborative exercises within ENFSI” provides information for the ENFSI Expert Working Groups (EWGs) on how to

organise effective proficiency tests (PTs) and collaborative exercises (CEs) for their members.

Forensic Handwriting Examiners should participate in regular externally generated proficiency tests. Participants in the test should follow the standard laboratory procedures for casework. They should not give the test any special treatment that would not be given in the same circumstances to casework.

The laboratory QA Manager should be informed of all CE/PTs undertaken.

Any results not in accordance with the expected outcome should be brought to the attention of the laboratory QA Manager as soon as possible.

# 8. HANDLING ITEMS

The examiner must ensure that any alterations to items within their possession are in accordance with the customer's requirements and are recorded within the casenotes.

The examiner must ensure that, whilst within their possession, there is no contamination (for example extraneous fingerprints and/or DNA) to items that might require further examination.

The examiner must consider the potential health hazards with the item (see paragraph 14) and take the appropriate precautions when handling any relevant items.

# 9. INITIAL ASSESSMENT

## 9.1 Introduction

In general all casework should undergo an initial case assessment to determine the suitability of the material for examination and the applicability of material submitted before any examination is undertaken.

## 9.2 Assessment at the laboratory

Before starting work on any case the examiner should carry out an assessment of the information available and the items provided for examination in light of the agreed customer requirement. The examiner should seek to redress any deficiencies through consultation with the customer.

Any work carried out will be to meet a particular customer requirement. At each stage, however, it is important that the course of action selected is based on an assessment of both the propositions put forward by the customer and the known alternative(s) to this.

The examiner should also make an assessment of the risk of contamination, or any other issue that could affect the integrity of the items before examination commences.

The examiner should then consider to what extent the proposition put forward by the customer can be tested and should also frame at least one alternative proposition favourable to the 'defence'.

The examiner should consider what they might expect to find if each proposition was correct and should make an assessment of the strength of the findings.

## 10. PRIORITISATION AND SEQUENCE OF EXAMINATIONS

Where there is more than one item and/or evidence type involved in the examination of a case then priorities and sequences for the examinations will need to be considered.

Before commencing any examinations within a case the following matters should be considered:

- the urgency and priority of the customer's need for specific aspects of the information
- the other types of forensic examination which may have to be carried out
- which evidential types or items have the potential to provide the most information in response to the various propositions and alternatives
- the perishable nature of any material that may be present
- health and safety or security considerations

### 10.1 Considerations for forensic handwriting examinations

The Forensic Handwriting Examiner must consider the most appropriate sequence of examinations, the implications of which will have to be considered in conjunction with:

- the availability of items for examination
- the amount of material, within the items, available for examination
- the potential value of the information available from each examination and the impact this has on the various propositions

## 11. RECONSTRUCTION

Not applicable

## 12. EVALUATION AND INTERPRETATION

When attributing the authorship of a piece of handwriting and/or signature, a number of propositions must be considered during the evaluation (see Appendix 5) as well as the interpretation of all of the information received and gathered relating to a specific examination process.

Each hypothesis must be considered equally against:

- the background information available about the case and the original expectations formulated during case assessment
- the significance of any findings from the examination

and an overall opinion formed related to the degree of support of the findings towards a proposition (over a specified alternative proposition).

# 13. PRESENTATION OF RESULTS

## 13.1 General

The overriding duty of those providing expert testimony is to the court and to the administration of justice. As such, evidence should be provided with honesty, integrity, objectivity and impartiality.

Evidence can be presented in court either orally or in writing. Only information which is supported by the examinations carried out should be presented. Presentation of evidence should clearly state the results of any evaluation and interpretation of the examination.

The Reporting Scientist's findings and opinions are normally provided, in the first instance, in written form, as a report or statement of witness, for use by the investigator and/or the prosecutor/court. Oral evidence may subsequently be required.

## 13.2 Written evidence

Written reports should include all the relevant information in a clear, concise, structured and unambiguous manner as required by the relevant legal process. Written reports must be peer reviewed.

Whilst formal advice is available on the format of reports and statements, the scope for consistency may be limited by the requirements of the criminal justice system for the country of jurisdiction. In general, however the following should be included:

- the unique case identifier
- the name and address of the laboratory(s) where the Forensic Handwriting Examiner is employed
- the identity of the Forensic Handwriting Examiner(s), and evidence of their status and qualifications where this is a requirement
- the signature of the Forensic Handwriting Examiner (s)
- the date on which the report/statement of Forensic Handwriting Examiner (s) was signed
- the date of receipt of the material that has been examined
- the name and status of the submitter
- a list of the material submitted, identified by source
- the questions to be addressed
- if relevant a comment relating to the condition of submitted material and its packaging when received, particularly where there is evidence of alteration, either by tampering, damage, contamination or any other means
- details of all relevant information received with, or in addition to the material
- the purpose of the examination
- details of the examinations/analyses carried out
- the results of the examination/analyses

- an assessment of the significance of the results in the context of the information provided
- the witness' expert opinion, where appropriate, and any findings which may influence it
- comment covering any material that was not examined, and the reasons for this
- details of any submitted material, or parts of such material, not being returned to the submitter, and the reasons why
- a page numbering system (for example in the format “Page x of y”)

The use of tables and/or photographic charts or illustrations, including interpretations and original data, can be a helpful aid in presenting the information clearly.

13.3 Oral evidence

Persons expected to present oral testimony should have received instruction and/or mentoring in the procedural requirements of the particular criminal justice system in which the evidence is to be presented.

Only information which is supportable by the examinations carried out should be presented.

When giving oral evidence the Forensic Handwriting Examiner should resist responding to questions that take them outside their field of expertise unless specifically directed by the court, and even then a declaration as to the limitations of their expertise should be made.

## 14. HEALTH AND SAFETY

There are occasional health hazard issues with items submitted for forensic handwriting examination, including biological contamination (for example excrement or biological powders) and chemical contamination (fingerprint treatment reagents). Caution must be taken when examining these types of items, and occasionally no examination can be undertaken.

## 15. BIBLIOGRAPHY

There are many books, journals and individual papers published on the subject of Forensic Handwriting Examinations. It is impossible to compile a complete list of all of these. The following list contains some of the significant publications that relate to the examination of Handwriting.

15.1 English language texts

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Ellen, D., Day, S. & Davies, C.
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Developments in Handwriting and Signature Identification in the Digital Age. Routledge, 2012

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Grundlagen, Methoden und Ergebnisse der Forensischen Schriftuntersuchung. Lübeck: Schmidt-Römhild, 1989

## 16. AMENDMENTS TO PREVIOUS EDITION

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# APPENDIX 1 - KEY KNOWLEDGE REQUIREMENTS FOR FORENSIC HANDWRITING EXAMINATION

## 1. SCOPE

1.1 All analysis involving the forensic examination and comparison of handwriting and signatures, both original and non-original.

1.2 The purpose of the examination is to determine whether or not there is evidence that two or more pieces of handwriting (including signatures) have a common authorship (that is to say “Is there any evidence that these pieces of handwriting were written by the same person?”).

1.3 The approach relies on a visual examination of the characteristics of the handwriting or signatures, and an assessment of the similarities and differences found between pieces of handwriting.

## 2. DETAILED KNOWLEDGE

2.1 Forensic Handwriting Examiners performing these examinations should have detailed knowledge of the following, gained through a comprehensive and documented training programme:

2.1.1 **Pertaining to Analysis:**

- Usage of minimum instrumentation (microscope, oblique light, IR luminescence and absorbance)
- Quality and quantity of handwriting (questioned and known)
- Grouping - management of large cases
- Different writing implements and inks (ball point, gel, liquid, pencil)
- Recognising copies (prints, contact copies)
- Systems of handwriting
  - Different alphabets (e.g. Roman, Greek, Cyrillic, Arabic etc.)
- Styles of handwriting/Classification systems
  - Upper-case
  - Cursive lower-case
  - Disconnected lower-case
  - Mixed writing forms
  - Numerals
  - Signatures (legible, illegible)
  - Graffiti
- Determination of general, individual (specific) and class characteristics
- Determination of pen-path
- Determination of fluency
  - Variation in pen-pressure
  - Tapering ends in individual characters
  - Connectivity between characters
  - Effects of speed in handwriting

- Effects of copying
  - Freehand
  - Tracing
  - Transferred / Transposed signatures (e.g. photocopies)
- Effects of disguise
  - Types of disguise (e.g. stencil, fluency)
  - Maintenance of disguise within both known and questioned writing

### 2.1.2 **Pertaining to Comparison:**

- Variations in handwriting
  - Within a piece of handwriting
  - Between two pieces of handwriting
  - Accidental variation
  - Long-term development of handwriting
- Graphic Maturity
  - Effects of complexity
  - Illiteracy
- External factors affecting handwriting such as
  - Writing position and writing surface
  - Visibility and lightning conditions
  - Motion
  - Guided / Assisted hand signatures
- Internal factors affecting handwriting such as
  - Illness and medication
  - Alcohol
  - Drugs
  - Handedness
  - Infirmity and age
  - Stress
- Definitions of similarities and differences
- Correct sampling techniques
  - Requested handwriting
- Dictate
- Correct writing style
- Sufficient quantity
- Disguise
  - Course of business handwriting
- Different sources
- Verification/identification
- Contemporaneous sampling covering the relevant time period
- Benefits of correct sampling process

### 2.1.3 **Pertaining to Evaluation:**

- Considerations
  - Significance of similarities and differences
  - Chance resemblance
  - Simulation

  - Disguise
  - Limited populations
  - Class characteristics (foreign writing)
  - Individual/general characteristics
  - Quantity and quality of handwriting
  - Limitations of copies
- Evaluative reporting
  - The use of probability as a measure of uncertainty
  - Formulation of propositions
  - Bayesian framework
  - Likelihood ratio
  - Different types of bias (for example cognitive bias)
- Different styles of conclusion scales in common usage
  - Certainty of conclusions and probabilities
- Presentation of evidence
  - Orally
  - In written format

2.1.4 **Pertaining to Digitally Captured Signatures:**

- Handling and preservation of electronic evidence
- Division of responsibilities between FHE and Forensic IT experts
- Understanding process underlying acquisition of a DCS
- Use of software designed to capture, extract and analyse DCSs
- Making use of information coded in metadata
- Knowing the different ways of encoding the characteristics of handwriting movements
- Comprehending the notion of local and global features
- Developed skills to plot and interpret DCSs illustrations and graphs
- Awareness of limitations concerning comparison and evaluation of both general and individual characteristics

# 3 GENERAL AWARENESS

3.1 Forensic Handwriting Examiners should also be able to demonstrate an awareness of the following:

- Basic knowledge of hand anatomy
- Basic knowledge of motor memory and motor learning process
- Teaching methods for handwriting and taught styles
- Distinguishing graphology from forensic handwriting examination
- Electronic systems for handwriting classification and retrieval
  - FISH
  - Graphlog
  - CEDAR-FOX
  - FlashID
- Electronic signature verification
- Challenges to forensic handwriting examinations
  - 1993 US court decision in Daubert v Merrell Dow Pharmaceuticals

        - Five critical considerations for admissibility of expert evidence
    - How to prepare for a challenge on the scientific nature of handwriting comparisons
- Various arguments governing the uniqueness of handwriting
- Non-destructive document examination methods
    - Indented impressions
    - Lighting and filtering techniques
        - Absorbance (Visual & infra-red)
        - Luminescence (Visual, infra-red & ultra-violet)
    - Printing processes
        - Non-impact printing
        - Impact printing
    - Commercial printing processes
    - Simple paper examinations
        - Use of lighting techniques
        - Shredded documents
        - Watermarks
- Partially destructive document examination methods, including
    - Thin layer chromatography
    - FTIR
    - Raman
    - SEM
- Other forensic examinations that may be impacted upon by a forensic handwriting examination
    - Fingerprint enhancement techniques
    - DNA examinations

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# APPENDIX 2 – TRAINING REQUIREMENTS FOR FORENSIC HANDWRITING EXAMINERS

## 1. BACKGROUND

1.1 This appendix details the requirements for the training of both a Reporting Scientist and an Analyst/Assistant (see paragraph 4.1.1. of the "Guidelines for Best Practice in the Forensic Handwriting Examination").

1.2 Whilst it is recognized the length of time taken to train a Reporting Scientist and an Analyst/Assistant is dependent on each individual organization, it is important that a number of significant steps and milestones is addressed in the training programme.

1.3 This document does not cover other aspects of the trainees training (including background information on other forensic activities and the role of a Forensic Scientist at court).

## 2. GENERAL INTRODUCTION

2.1 Each organization must:

- Generate an individual training programme for each new trainee that covers the whole training period of the trainee. An example of a suitable Training Programme is shown at the end of this Appendix.
- Ensure that all relevant aspects of the "Key Knowledge Requirements for Forensic Handwriting Examination" (Appendix 1) are covered within the training programme.
- Ensure that there is a periodic assessment of the development of the trainee as a Forensic Handwriting Examiner.
- Ensure that there is a clear and unambiguous process of final assessment of the capabilities of the trainee.
- Ensure that there is on-going training and assessment of all Forensic Handwriting Examiners within your organization.

2.2 The duration of the training period shall be determined by the laboratory management in conjunction with the trainee.

## 3. PHASE 1 - INITIAL TRAINING

3.1 Prior to commencing training, all trainees must have a general overview of the training programme, including a defined timetable with significant milestones.

3.2 During the initial period of training, all trainees should be introduced to:

- The specific methodology used within the organisation
- Referenced textbooks and relevant journals and scientific papers
- Test item handling
- Use of relevant instrumentation

- Basic notetaking, including the use of specific forms (if relevant)

## 4. PHASE 2 – USE OF TRAINING CASES/MOCK MATERIAL

4.1 Use of specifically generated material (with known results) to examine specific features encountered within handwriting, for example:

- types of handwriting including
  - Natural handwriting
  - Disguised handwriting
  - Copied/simulated handwriting
- types of writing instrument
- levels and features of fluency
- differences in individual character construction, and combinations of characters

4.2 The purpose of this section of the training is to install the knowledge of the significance of individual characteristics as opposed to class characteristics

4.3 This section of the training programme will also introduce the comparison process as well as introducing the trainee to the wide variations in characteristics encountered in handwriting.

## 5. PHASE 3 - INTRODUCTION TO CASEWORK MATERIAL

5.1 This phase introduces the trainee to the critical aspects of examining casework material, including

- Introduction to any relevant casework management systems employed by the organisation
- Understanding the purpose of submission and identifying what the potential outcomes of the examination may be
- Determining that suitable and relevant material has been submitted and determining what other material may be required to complete the examination
- Awareness of the other forensic opportunities that may be available, including other aspects of forensic document examination
- Awareness of the impact of the examinations on other areas of forensic science, including any potential contamination issues
- Assessment of known and questioned material for internal consistency

## 6. PHASE 4 - CONSOLIDATION

6.1 This phase of the training is critical as it will introduce the trainee to the wide-range of material submitted to the laboratory and will involve many separate examinations, potentially involving many different case examples.

6.2 Features to be encountered at this stage will also include:

- Introduction to various types of material

- Introduction to various case situations, including both size and complexity, and how they can be managed
- Awareness of relevant databases including IHIS (which includes international copybook styles and handwriting samples)
- Introduction to the relevant conclusion scales
- Preparation of forensic reports, including court comparison charts
- Advising the submitting organization/individual on the need for suitable samples

6.3 Each specific case should be reviewed by the trainer within a reasonable timeframe.

## 7. PHASE 5 - FINAL COMPETENCE ASSESSMENT

7.1 At the culmination of the documented training period, the trainee will undertake a series of competence assessments. These assessments should include:

- Review of the casework material examined during Phases 3 and 4 of the training programme. This material will form a portfolio of material which can be assessed both internally, and if appropriate by external scrutiny
- Successful outcomes from a number of proficiency tests
- Presentation skills, relating specifically to forensic handwriting comparisons
- Report writing skills

7.2 Following confirmation that the trainee is competent and confident to present evidence in court, the trainee will be considered suitable for undertaking and reporting casework.

## 8. PHASE 6 - CONTINUED RE-EVALUATION

8.1 It is important to remember that the Training and Final Competence Assessment is a milestone in the Trainees' progress. All Forensic Handwriting Examiners must maintain their competence. This can be achieved via a number of processes but should include:

- Regular participation in testing procedures (e.g. collaborative exercises, proficiency tests)
- Peer review of casework
- Maintenance of competence through regular discussion and independent examinations
- Maintained awareness of developments in the field through literature, training sessions and seminars/workshops

8.2 Following any prolonged absence or period of inactivity with regards to handwriting comparisons the Forensic Handwriting Examiner must undergo a reassessment for competence (similar to that described in Phase 5, paragraph 7).

***Typical example of training programme. Detailed timings will be dependent on organisational requirements.***

## Forensic Handwriting Examinations – Training Programme

## Name: James Smith

## General information

The forensic examination and comparison of handwriting is one of the most subjective of forensic disciplines and it is essential that anyone being trained in the subject is given adequate time to gain experience. The only way to gain experience is by examining handwritings – and plenty of them – and being told about the significance of handwriting features by an experienced handwriting expert.

In reaching conclusions, and expressing opinions, Forensic Handwriting Examiners have to make assessments of the significance of the handwriting features under examination. To ascribe high significance to relatively common features is a sure and certain way to an erroneous conclusion. Therefore it is essential that the trainee examines handwriting on a daily basis and not just in a piecemeal or occasional manner (ENFHEX BPM).

| Activity | | Training Time | Target date | Completion | |
|---|---|---|---|---|---|
| | | | | Trainee | Trainer |
| Initial Training | • Introduction to the Quality System and Methodology<br>• Review of relevant textbooks and scientific papers<br>• Test item handling<br>• Introduction to basic notetaking<br>• Use of relevant instrumentation | | | | |
| Initial case notetaking | • Confirming relevant items<br>• Identifying requirements (Handwriting comparison, signatures, indented impressions etc.)<br>• Notetaking (including ink types, colours, printing process etc. | 3 days per week (minimum) | | | |
| Detailed notetaking | • Magnification<br>• Sketching handwritings<br>• Highlighting features<br>• Individual features (proportions, shapes, structures) | 3 days per week (minimum) | | | |
| Assessment of the significance of handwriting features | • Pictorial similarity<br>• Chance resemblance<br>• Quantity/Quality of handwriting | 3 days per week (minimum) | | | |
| Interpretation of the significance of handwriting features | • Management of large casefiles<br>• Grouping of handwriting | As and when cases become available | | | |

| **Activity** | | **Training Time** | **Target date** | **Completion** | |
|---|---|---|---|---|---|
| | | | | **Trainee** | **Trainer** |
| External influences | • Disguised handwriting<br>• Copying and forgery<br>• Effects of drugs and alcohol on handwriting<br>• Effects of illness and age on handwriting<br>• Writing with the unaccustomed hand<br>• Positional influences | As and when cases become available | | | |
| Reporting Results | • Conclusion scales | On-going | | | |
| Report writing | • Construction of generic report | On-going | | | |
| Competence Assessment | • Use of in-house and externally developed QA Trials<br>• Review of casework material<br>• Report writing skills | As determined by Trainee and Trainer | | | |
| Background reading | • General Documents and Handwriting protocols | On-going | | | |

Notes:

- The bulk of the training will consist of shadowing an expert using case examples. During the preliminary aspects of the training both in-house generated examples and previous casework will be utilised.
- All aspects of training will be regularly reviewed and discussed with the trainee
- Any slippage in the timetable may result in the “Competence Assessment” date being postponed.

# APPENDIX 3 - OVERVIEW PROCEDURE FOR FORENSIC HANDWRITING EXAMINATIONS AND COMPARISONS

## 1. INTRODUCTION

The purpose of the examination is to determine whether or not there is evidence that two or more pieces of handwriting have a common authorship (that is to say “Is there any evidence that two or more pieces of handwriting were written by the same person?”). The approach relies on a visual examination of the characteristics of the handwriting, and an assessment of the similarities and differences found between pieces of handwriting.

## 2. SCOPE

2.1 The scope of this procedure covers the forensic examination and comparison of handwriting (in all forms including signatures and graffiti), both original and non-original.

## 3. PRINCIPLES

3.1 There are five main principles that need to be considered when examining handwriting. Each of the following principles is dependent on the quality and quantity of available handwriting.

3.1.1 No two people write exactly alike.

3.1.2 No one person writes exactly the same way twice, and no two naturally written signatures are exactly the same.

3.1.3 The significance of any feature, as evidence of identity or non-identity, and the problem of comparison becomes one of considering its rarity, complexity, the relative speed and naturalness with which it is written, and its agreement or disagreement with comparable features.

3.1.4 No one is able to imitate all of the features of another person's handwriting ***and*** simultaneously write at the same relative speed and skill as the writer that he/she is seeking to imitate.

3.1.5 In those cases where the writer disguises their normal handwriting or imitates the handwriting of another person, it is not always possible to identify the author of the handwriting.

## 4. HEALTH & SAFETY

Occasionally items are submitted which have been:

- Treated with chemical reagents to enhance fingerprints
- Exposed to biological material (for example blood products etc)

Caution must be maintained when examining this type of material, and on occasion the contamination may be such that, on health and safety grounds, no examination can be undertaken.

## 5. TERMS AND DEFINITIONS

For Terms and Definitions see Appendix 8.

## 6. PRESERVATION AND HANDLING OF ITEMS

6.1 All test items should be handled as little as possible, and normally by an individual wearing gloves or using tweezers.

6.2 All test items should be protected from damage by packing securely in plastic bags or envelopes.

6.3 The sequence of all relevant tests should be assessed prior to any examinations. Consideration should be given to the potential contamination of the items during the handwriting examination. For optimum recovery of information the items should be examined by the Forensic Handwriting Examiners prior to any destructive examination (such as fingerprint treatments and/or chemical ink analysis).

## 7. EQUIPMENT/INSTRUMENTATION/OPERATING CONDITIONS

The following is the minimum instrumentation recommended to undertake a complete handwriting examination:

- A microscope, or other magnifying instrument, with sufficient magnification to allow the examination of the fine detail of the handwriting
- A suitable light source with enough intensity of light to allow the examination of the fine detail of the handwriting
- A suitable lighting system that allows for infra-red absorbance and luminescence
- Oblique lighting

## 8. CROSS REFERENCED MATERIAL

- Best Practice Manual for the Forensic Handwriting Examination
- Appendix 1 - Key Knowledge Requirements for Forensic Handwriting Examination
- Appendix 2 - Training Requirements for Forensic Handwriting Examiners
- Appendix 8 - Terminology and abbreviations used in Forensic Handwriting Examination

# 9. PROCEDURE

9.1 The flow chart (section 14) shown at the end of this appendix gives a schematic representation of the steps undertaken during the course of a forensic examination and comparison of handwriting.

9.2 The notes detailed below give some of the features that should be assessed during the course of the examination. It may well be that some of these features are not relevant in every case, and should be addressed on a case by case basis.

## 9.3 Quality and quantity of handwriting

9.3.1 Features to be noted include:

9.3.1.1 Whether the handwriting is original or in the form of a copy document. If possible and practicable examine the original documents. [**Note**: If the handwritten entries are copies of originals, continue with this procedure (making the relevant observations - where possible), but see section 9.7 of this procedure before continuing].

9.3.1.2 The physical and/or mental state of an individual can have a significant impact on the handwriting of that individual. Consider the potential impact on the writing of the physical and/or mental state of all individuals concerned including:

- Fatigue
- Illness
- Intoxication
- Age of individuals involved

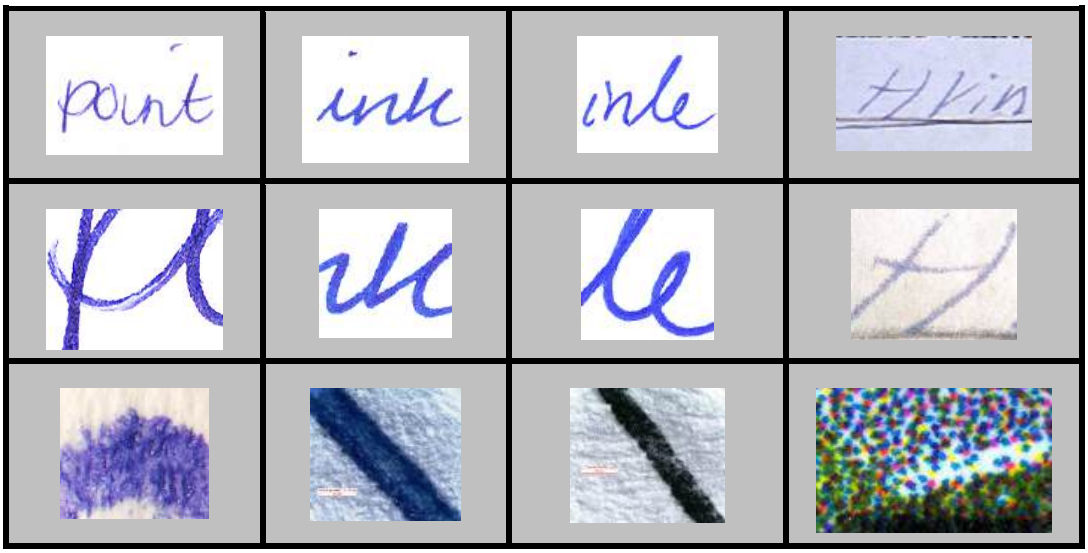
[**Note**: The effects seen are used for comparison purposes only and while it may be possible to give a limited, advisory comment on the physical state of an individual, an FHE can draw no inference on the mental state of an individual on the basis of the handwriting characteristics.]

9.3.1.3 Any external physical circumstances which may affect the overall appearance of the handwriting (e.g. writing made while standing up, writing on a rough surface).

9.3.1.4 Where applicable, any information supplied concerning the nationality or ethnic origin of the potential writer (e.g. English, French, Arabic, Asian etc.).

9.3.1.5 Writing implement

- Type of writing implement (pencil, pen, spray paint etc.), see figure 1.
- Type of ink (for example ball point pen, liquid ink or gel ink etc.), see figure 1.
- Colour.



(a) (b) (c) (d)

Fig 1. Different types of writing implement (a) ball-point pen ink (b) liquid ink (c) Gel ink (d) handwriting reproduced by an ink-jet printer.

9.3.1.6 Assess the amount of available material for examination and comparison

- Is there sufficient material to be able to assess the range of variation, or are there limitations with the amount of material available?
- Are there any other limitations within the known handwriting or within the questioned handwriting?

9.3.1.7 Determine the type or style of handwriting submitted for examination

- Block capitals. Disconnected upper-case characters (occasionally through speed of writing the characters demonstrate some degree of connectivity).


Fig 2. Examples of different pieces of upper-case handwriting. This is sometimes referred to as “printed handwriting” or block capital handwriting.

- Disconnected lower-case handwriting. Lower case handwriting with each character disconnected from the neighbouring characters. Each individual character is often distinct and legible.

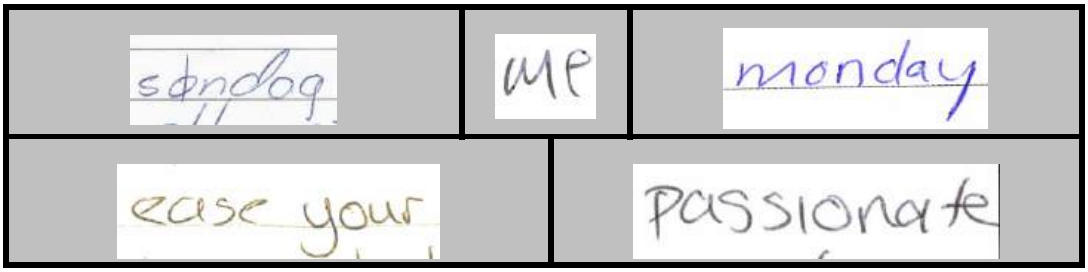



Fig 3. Examples of different pieces of disconnected lower-case handwriting

- Connected lower-case handwriting. This style of handwriting is often also known or referred to as cursive or “joined-up” handwriting. There is normally a high level of connectivity between characters.


Fig 4. Three examples of “joined up” or cursive lowercase handwriting showing a degree of connectivity between each character.

- Mixed writing forms (either mixed cursive and disconnected, or mixed upper-case and lower-case)


Fig 5. Words that contained a mixture of upper-case and lower-case characters (left) or a mixture of connected and disconnected characters (right).

- Numerals

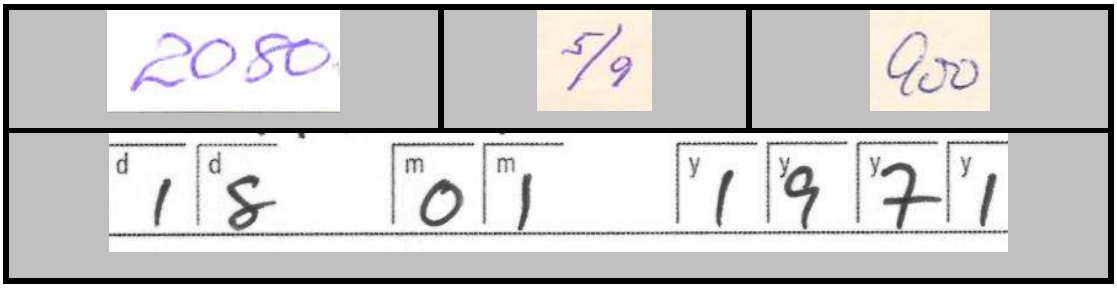



Fig 6. Examples of numerals.

- Graffiti – like signatures a particular type or style of handwriting which has its own unique requirements when being examined. [**Note**: Caution needs to be taken when examining this type of handwriting]

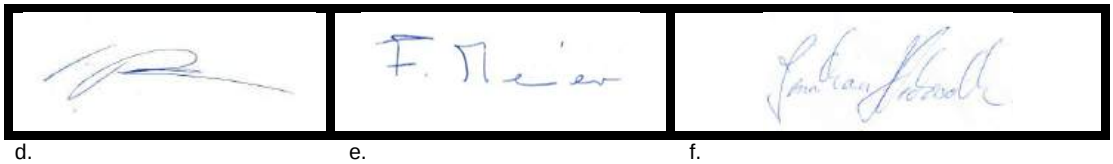
Fig 7. Various examples of graffiti, showing examples of handwriting (left) and more artistic styles (centre and right).

- Signatures – A signature is a handwritten entry, produced with a purpose of authenticating a document and typically referring to the signatory's name. Signatures vary with regards to their complexity and degree of automation, both of which – from forensic point of view – influence their appropriateness for identification. Initials or very short signatures (examples **a,** and **g**) may not contain enough characteristics to enable identification of the writer as they can be easily copied by other people. The higher the complexity of a signature, regardless whether legible or illegible, the more difficult its simulation becomes. Complexity depends on skill, number of writing movements, changes in writing direction, allograph design, speed of execution etc. Automation is the ability of the writer to produce the whole signature or a large part of it with a single, well trained movement rather than executing particular allographs or small portions one after another. The higher the level of automation and the uniformity of the signatures of a given individual, the higher the simulation difficulty becomes and the lower the likelihood of a chance match. The images below represent different styles of signatures ordered by length and complexity.

Legible signatures

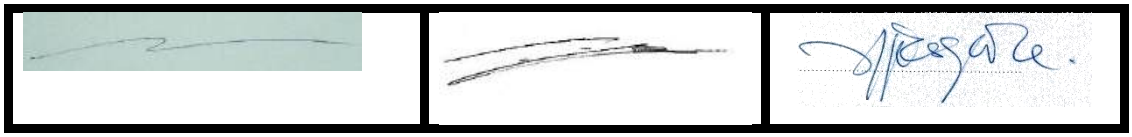
a. b. c.

Mixed style signatures



d. e. f.

Illegible signatures



g. h. i.

Fig 8. Examples of legible (a, b and c), mixed style (d, e and f) and illegible signatures (g, h and i). Signatures (c), (f) and (i) can be considered complex.

## 9.4 General characteristics

9.4.1 Features to be noted for both handwritten entries and signatures include:

- Style and legibility
  Features which may be noted in this category relate to the general appearance, such as the “angularity”, how “readable” the handwriting is etc. A lack of legibility, especially in signatures, is often encountered.

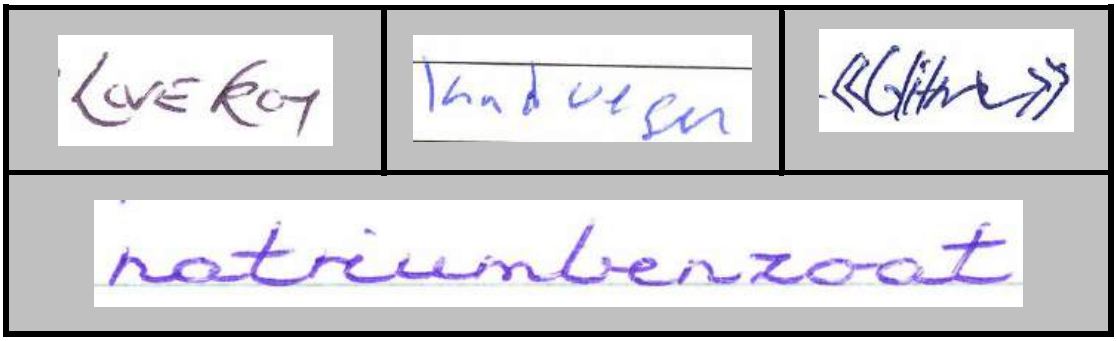


Fig 9. Examples of both legible and illegible handwriting.

- Size
  Features such as the relationship between the size of the characters and the writing lines. Occasionally the size of the paper may constrain the space for the handwriting and this may affect recognizable features.

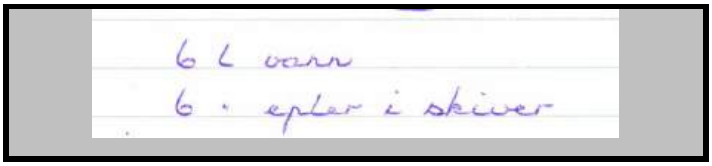


Fig 10. Images showing relative height of handwriting compared with printed lines.

- Proportions
  Relative size of letters in words, for instance a larger capital letter at the beginning of each word.

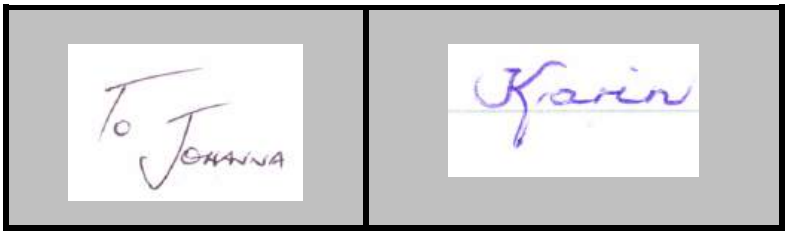


Fig 11. Two pieces of handwriting showing distinctly different sizes to characters within words.

- Spacing
  Reference can be made to the relative spacing between individual characters, between words etc.

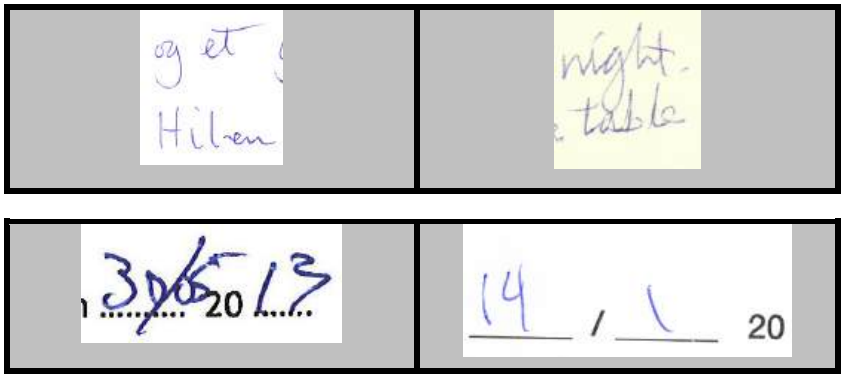


Fig 12. The effect of limited space on handwriting as well as examples of spacing in routine handwriting.

- Slope
  Note the upright, backward, forward or variable slant of the handwriting (occasionally the handwriting of an individual varies with the change of angle of writing)

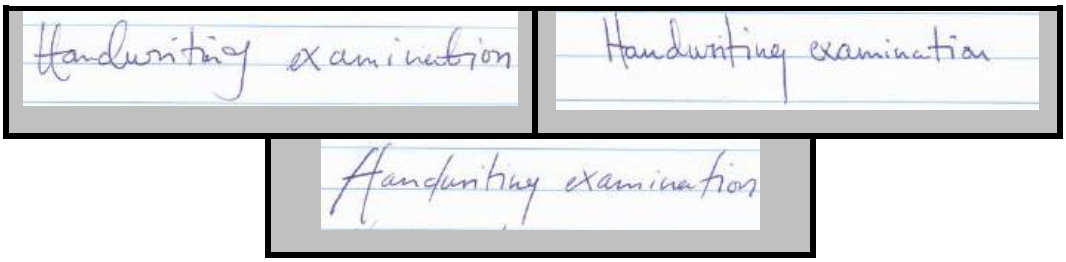


Fig 13. Three examples of handwriting. All produced by one person showing the effects of altering the slope of the handwriting.

- Fluency/Pressure
  Reference can be made to whether the writing appears to be skilfully or poorly produced, whether there is hesitation in the pen line (pen lifts, tremor etc.), whether the writing line is smooth flowing and whether the writing line has variable pressure, or constant, hard pressure. Three main elements of fluency are connective strokes between characters, tapered ends within characters and variation in pressure within the writing

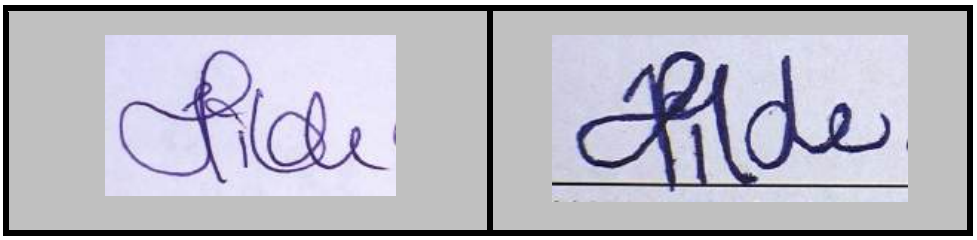
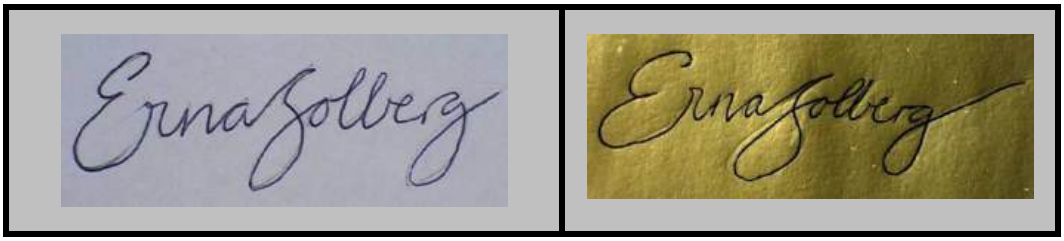


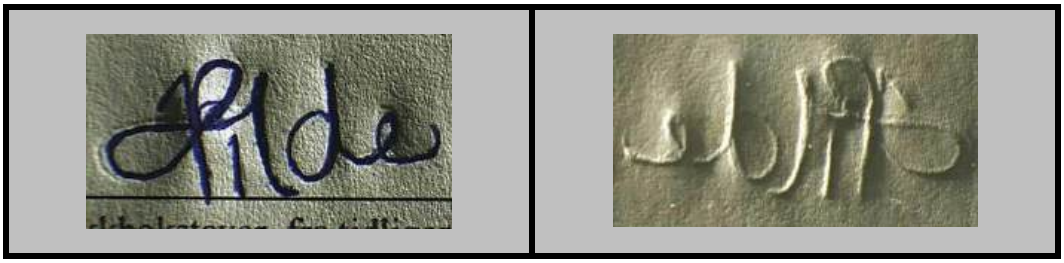
Fig 14. Images showing the differences in fluency between two words. The left hand image shows connective strokes, tapered ends and variation in pen pressure, the right hand image lacks these features.

- Tracing
  Check if there is evidence of tracing, including guidelines. If present these should be noted.



(a) (b)

Fig 15. Example (a) shows a signature with pencil guidelines at certain point, whilst image (b) shows indented guidelines around the edge of the signature.



(a) (b)

Fig 16. Above images (a) and (b) show the front and back of a signature with oblique light.

- Layout
  Some consideration of the layout of the handwriting should be mentioned. The layout of a document may be the individual trait of the person who made the entries.

## 9.5 Detailed examination

9.5.1 Features to be noted include:

- Individual character shape
  Roundness of the character, angularity etc.

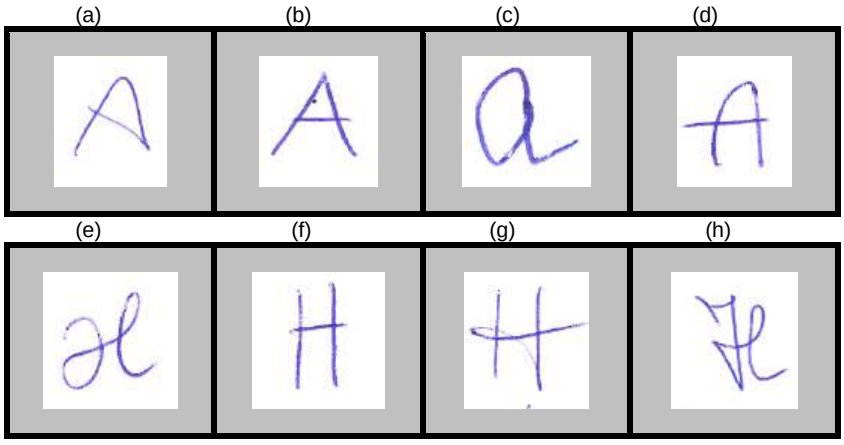



Fig 17. Images (a) to (d) show four different block capital ‘A’s produced by the same person. The same person produced the range of ‘H’s shown in images (e) to (h).

- Individual character proportions
  For instance the relative size of the top loop in a “B” compared with the bottom loop

Fig 18. Images showing examples of the letter "B" demonstrating different proportions to the individual character.

- Individual character construction
  The pen path over the surface of the document, the number of strokes in a character etc.

(a) (b) (c) (d) (e) (f)

Fig 19. Images (a), (b) and (c) show three different constructions for an upper-case ‘E’, whilst images (d), (e) and (f) show variations in the pen-path for the letter ‘G’.

- Individual parts of the signature
  Note or sketch the individual parts of the signature. Note whether the parts of the signature are rounded, angular, oval etc. in shape.

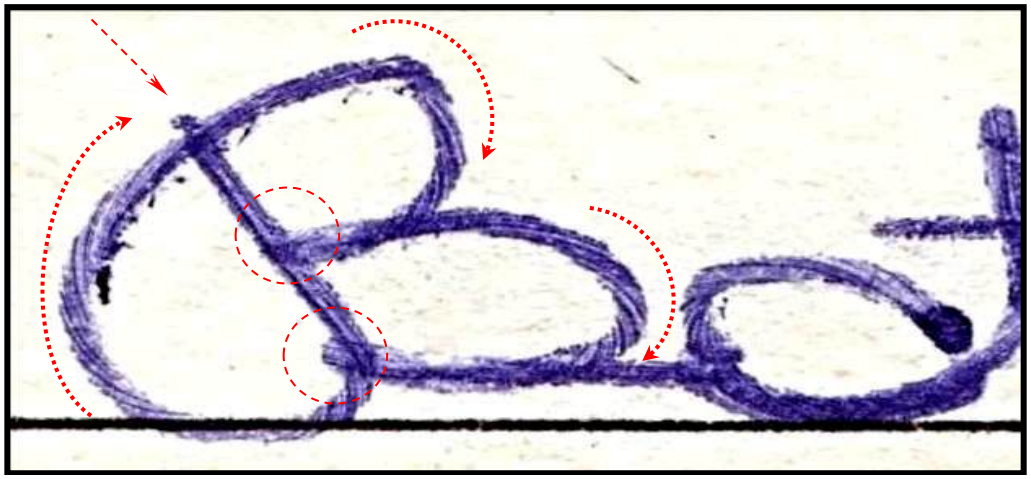


Fig 20. Images showing the various different components to the initial character in a word.

- Character combinations
  The relative proportions of two or more characters together, for instance “th” joins or “ch” joins.

- Connection of letters
  How are two characters joined, for instance at the top or at the bottom.

- Relative fluency and pen pressure
  How the pen pressure changes within a character/word and the relative positions between two words.

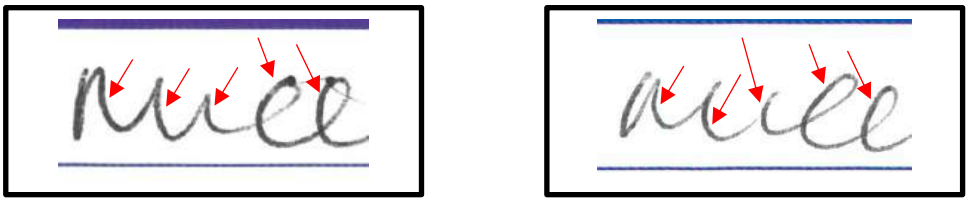
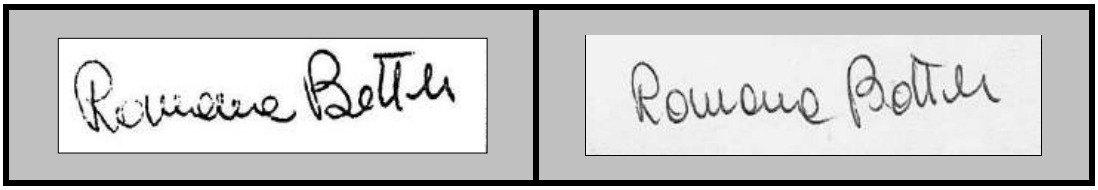


Fig 21. Images showing the variation in pen pressures, at the same points, between a questioned signature (left) and genuine signature (right).

## 9.6 Examination of copy documents

9.6.1 Copy documents (such as photocopies, faxes, microfiche copies) do not contain all of the detail present in the original documents, and the quality of copy documents varies from item to item. If an examination and comparison is to be made using copy documents, the following observations must be made:

- Determine the clarity of the copy document. Is the handwriting sufficiently detailed for comparison purposes?
- Comment in the notes on the fact that copy documents have been examined.
- There must be a disclaimer that the examination is commenting only on the handwriting and is not commenting on the authenticity of the document.
- There must be comment within the notes that the results of any examination may be limited due to the fact that copy documents have been examined.



(a) (b)

Fig 22. Image (a) shows a poor quality photocopy, with much detail lost whilst image (b) shows a good quality copy with great detail features.

9.6.2 If the clarity of the copy document is poor, then comment should be made to this effect, and no significance should be attributed to any comparison made.

# 10. COMPARISON PHASE

10.1 On completion of the analysis (or assessment phase) of the examination (sections 9.1 to 9.6 of this Appendix) the examiner is likely to undertake the comparison phase (although the Analysis and Comparison phases may not be mutually exclusive).

10.2 The mechanisms involved in the Comparison Phase are detailed in Appendix 4 and these include:

- Notes on the similarities and differences in the quantity and quality of the handwriting
- Notes on the similarities and differences in both the general and detailed layout of a document, as well as baseline features, relative proportions of character combinations and the slope and size of the handwriting
- Notes on the similarities and differences in the fluency of the handwriting
- Notes on the similarities and differences in detailed features, such as the pen path and individual character constructions
- Notes on the similarities and differences in the range of variation, not only within a single piece of writing but between two (or more) pieces of handwriting

## 11. EVALUATION PHASE

11.1 On completion of the examination there is a detailed assessment of all of the relevant findings for their significance (see Appendix 5).

11.2 The assessment will include a determination of the strength of all relevant similarities and differences identified during the examination.

11.3 Once assessed a conclusion is formulated using the relevant conclusion scale.

## 12. QUALITY ASSURANCE AND COMPETENCY

12.1 A competent examiner should be able to use the Instrumentation listed in section 7.

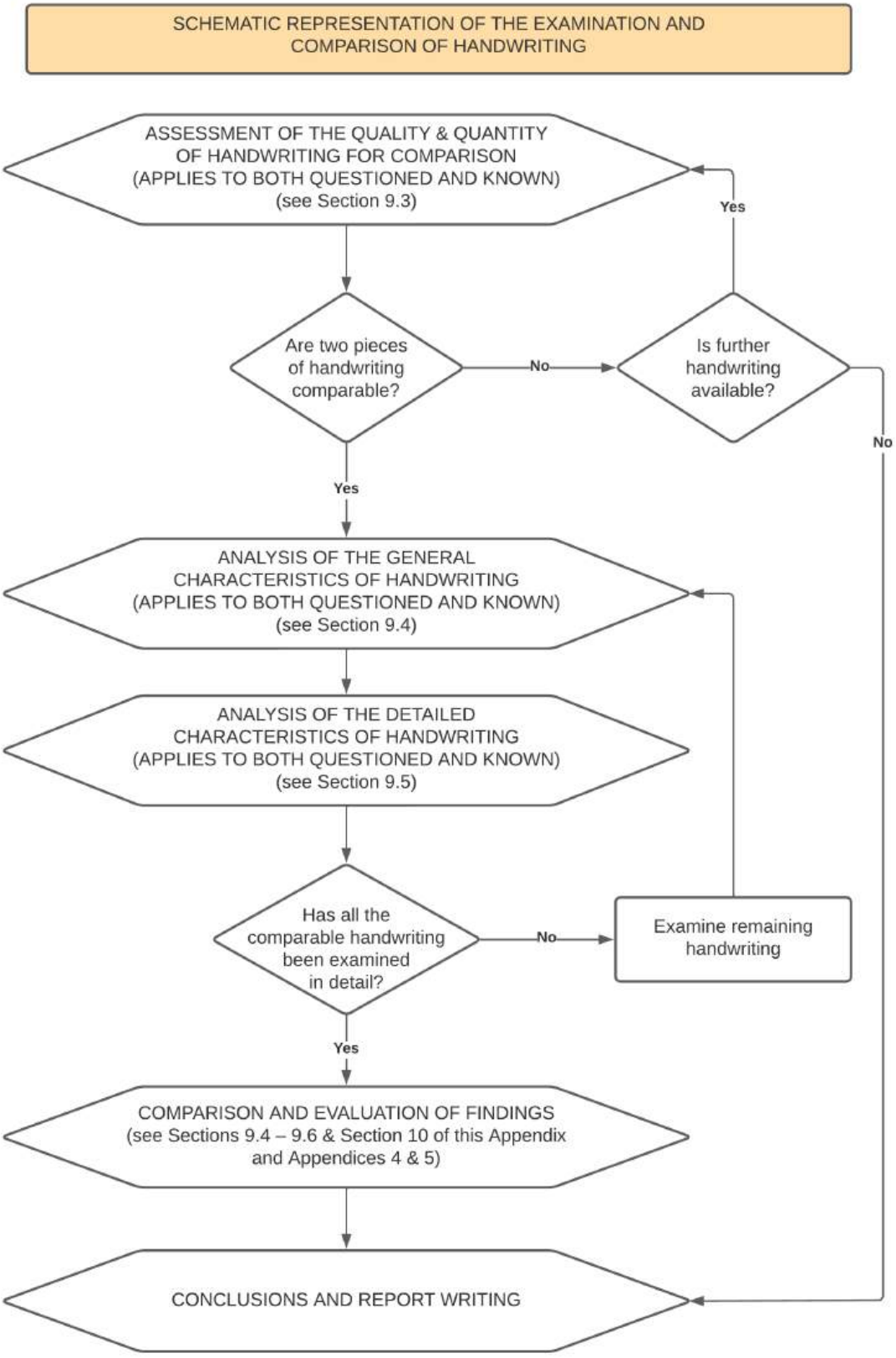
12.2 The competencies relevant to the Examination and Comparison of Handwriting are summarised in the Key Knowledge Requirements for Forensic Handwriting Examination.

12.3 The specific quality procedures for each department should be detailed by the relevant department.

## 13. REFERENCES

13.1 There are many books, journals and individual papers published on the subject of Forensic Handwriting Examinations. It is impossible to compile a complete list of all of these. The principle books are detailed in section 15 of the BPM.

# 14. OVERVIEW OF THE EXAMINATION PROCESS



# APPENDIX 4 - COMPARISON

## 1. INTRODUCTION

1.1 The following appendix aims to provide a number of tools and procedures which can be used in the forensic comparison of handwriting. It is accepted that over time laboratories have developed their own “in-house” procedures for comparing handwriting, with slight variations in approach, but this appendix is designed to assist in developing a more consistent application.

1.2 Comparison, within the framework of the handwriting examination process (processes such as ACE, ACE-V or double ACE), is the second phase of examination.

1.3 The comparison phase follows after the questioned (Qn) and the known material (Kn) have been assessed as being suitable for comparison and, strictly speaking, after all features have been assessed separately in both the Qn and Kn (the “analysis” phase). In practice, the analysis and comparison steps may be carried out simultaneously, and not necessarily performed sequentially. Nevertheless, it is advisable to understand the processes involved in the comparison phase, and to proceed as systematically as possible.

1.4 Clear documentation of both the analysis and comparison phases is critical and will also be addressed in this appendix.

1.5 Comparison is followed by the evaluation of the findings. It is important to see evaluation as a separate phase in forensic handwriting comparison, which should take into account the complete findings from both the analysis and comparison steps.

## 2. SCOPE

2.1 The scope of the comparison phase is the systematic assessment of each handwriting feature in both the questioned and the known handwriting, to determine if the feature is similar or not, and to document the findings.

2.2 While the most basic outcomes from comparing a single feature is that they are either similar or different, there are many other possible observations that need to be considered, for example:

- when comparing larger amounts of text, the process is effectively comparing the range of variation present within the questioned material with the range variation of the known material for the same feature. Thus, the distribution of different variants of the same feature might need to be taken into account.

- considering limited quantities of known handwriting may lead to missing features, where the specific feature of the questioned writing is not present within the known material and therefore cannot be compared.

2.3 A comparison does not necessarily need to take place between one set of questioned writing and one set of known writing. Scenarios where several questioned texts need to be compared to each other, or where more than one questioned or known set of writings need to be examined do frequently occur in casework. These can always be broken down to one-to-one comparisons, such that they correspond to the same process.

# 3. DEFINITIONS

## 3.1 Handwriting Characteristics

3.1.1 The general and detailed handwriting characteristics that can be compared are described in sections 9.4 and 9.5 of Appendix 3.

## 3.2 Definitions of similarities, differences, and missing features

3.2.1 One of the most useful and detailed definition of similarities and dissimilarities was provided by Found and Rodgers (1998).

3.2.2 "**Similarities** are pictorial, structural [or dynamic] features that appear consistent between [questioned and the known writings]. The similarities can be observed in terms of the way the strokes are concatenated into [character, character combinations], word formations, the features that are able to be described and the relative placement of [writing elements]."

3.2.3 "**Differences** are pictorial, structural [or dynamic] features that appear dissimilar between [questioned and the known writings]. The dissimilarities can be observed in terms of the way the strokes are concatenated into [character, character combinations], word formations and the features that are able to be described. The criteria for features to be described as different are that they are fundamental to the pictorial or structural character of the writing and are not shared between the bodies of questioned and standard writings."

3.2.4 In some publications terms like significant similarities or differences, as well as individual characteristics are used. Those terms refer to the value attributed to characteristics during the evaluation of the findings and are therefore avoided in this appendix. During the comparison phase, it is best not to prematurely attribute evidential value to the findings, because this could hinder the analysis of the full catalogue of handwriting characteristics and lead to bias.

3.2.5 The term "missing features" refers to general characteristics or a particular character from the questioned writings that are missing from the known writings. Those features cannot be compared and assessed as similar or different. This can occur due to limited quantity of the known material or with respect to uncommon, rare features.

# 4. COMPARISON AS PART OF THE HANDWRITING EXAMINATION PROCESS

## 4.1 General considerations

4.1.1 During the analysis phase, not only does the examiner make an assessment of the suitability of the questioned material (Qn) and the known writing (Kn), but also an inspection of all of the handwriting characteristics in both groups of handwriting, including detailed case notetaking. The comparison phase therefore involves not only a systematic comparison of characteristics, supported by the notes taken during the analysis phase, but also, where necessary, a review of the assessments of questioned and known samples.

4.1.2 Both the analysis and the comparison steps should be documented by noting the observations for each feature in the questioned and the known handwriting, as well as the outcome (similar, different, missing; see sections 3.2 and 4.2.5). Features that cannot be compared (e.g. features that are not present or not assessable in Qn, or features missing from Kn) should be clearly marked (i.e. by striking through).

4.1.3 The flow chart (see section 7) demonstrates the underlying sequence of steps involved in the comparison phase and details some of the possible outcomes. While it depicts a standard procedure, it is important to keep in mind that deviations are quite common in forensic science, since casework does not represent a standardized task and cannot be fully covered. The process map is a simplification of the actual process.

## 4.2 Detailed considerations

4.2.1 Analysis and assessment of characteristics

4.2.1.1 The comparison process starts with the outcome of the analysis phase, where a) the questioned (Qn) and the known (Kn) material has been found to be “comparable” and b) all the characteristics from Qn and Kn have been assessed.

4.2.1.2 For each feature (see sections 9.4 and 9.5 of Appendix 3) in the questioned writing, it must first be checked whether relevant characteristics can also be assessed in known writings. If not, that particular characteristic cannot be compared, resulting in a missing feature.

4.2.2 Comparison of characteristics considering variation

4.2.2.1 Next, each characteristic needs to be compared. Depending on the number of occurrences in Qn and Kn as well as the variation of the feature in Qn and Kn, different paths can be taken in the flow chart. This shows that the possible outcomes of a comparison of a single feature is not just a similarity or a difference (see section 4.2.3), but can be more nuanced, since various aspects need to be taken into account (see section 4.2.4).

4.2.3 Findings from the comparison

4.2.3.1 The basic findings of the comparison phase are that each single characteristic can be similar, different or not comparable (e.g. due to missing features or due to difficulties in assessing certain characteristics). The assessment of what is

similar and what is different can be trivial in some cases and more complex in others (see section 3.2 for definitions and section 5 for examples).

4.2.3.2 Since this process is repeatedly applied to each characteristic, the result of the entire comparison phase can be considered as a complex combination of similarities, differences, intermediate forms, and missing features.

4.2.4 Parameters that need to be considered during comparison

4.2.4.1 A critical component of the comparison of handwriting is the suitability of the known material. To facilitate comparison, some parameters should be met by the known samples:

- the known material should contain handwriting which is similar to the questioned sample in writing system, writing style, context of document type[1], writing implement used,
- the known material should contain all characters present in the questioned text,
- the known material should be of sufficient quantity, such that the variation of the writer can be correctly assessed,
- depending on the case, the known material should be dated close to the questioned entries.

4.2.4.2 If those parameters are not fulfilled, suitability of the known material may be restricted. Those limitations need to be taken into account during the comparison. It may be impossible to properly compare particular characteristics leading to missing features or an imprecise assessment of the variation.

4.2.4.3 If part of the known material is more suitable for comparison to the questioned writing, those entries might need to be given more importance for the examination.

4.2.4.4 When working with non-original handwriting or with items produced with particular writing implements (especially liquid ink, such as in fibre-tip pens) or when the writing has been degenerated (e.g. by contamination with dirt, water or chemical reagents), some important handwriting characteristics, such as writing pressure, line quality or even writing direction, are difficult or impossible to correctly assess. This uncertainty needs to be taken into account when estimating if a feature is similar or different to the known samples.

4.2.4.5 At this phase, when deciding for each characteristic of the questioned writing if it is similar or different to the known writings, possible explanations for the findings, such as disguise or simulation, should not yet be taken into account. The interpretation with regards to those (sub)-hypotheses belongs to the evaluation phase of the forensic handwriting examination.

1 For example a quick and casual draft of a shopping list may be inadequate to be compared to an official text like a testament

4.2.5 Documentation and notetaking

4.2.5.1 Documentation and notetaking during the analysis and comparison phases of the forensic handwriting examination process are important to ensure traceability. To facilitate the workflow and conform to quality assurance procedures predefined forms (including important information such as case number, examiner name, and date) may be used (notetaking forms are presented in appendix 6, section 11). Notes and documentation should be clear and sufficient for another examiner of the same laboratory to be able to fully comprehend them.

4.2.5.2 To assist documentation of the findings different overviews may be prepared on such forms to be used offline or online:

- Tabular overview of scanned/copied letters and characteristics,
- Tabular overview of handmade sketches of letters and characteristics,
- Overviews of scanned/copied signatures.

4.2.5.3 The findings from the comparison may be documented in different ways, such as:

- Written notes describing the characteristics and the findings,
- Drawings and markings on prepared overviews,
- Drawings and markings on copies/scans of the questioned and known writings,
- Use of signs to document the findings – see Box 1 for an example

Examples of how to illustrate, describe and evaluate particular similarities and differences observed between the Qn material and the Kn samples is proposed below. In this example the material was assessed on a 5-point scale, in the following categories:

- clearly similar (++)
- similar (+)
- inconclusive (~)
- different (-)
- clearly different (- -)
- missing feature / not comparable (**N/C**)

Each laboratory will have their own approach to "scoring" the level of similarity or difference, but it is important to document the specific scale within their case notes and management system.

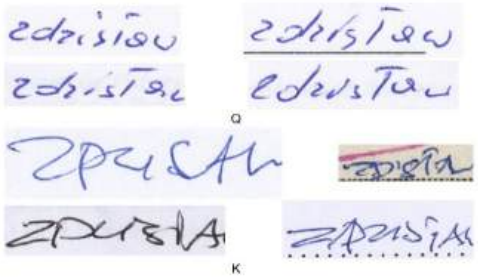
Box 1 – Potential assessment criteria for each of the features compared

4.2.5.4 Examples of the type of recommended notetaking are indicated in Boxes 2 to 15 in section 5 of this appendix and in the note taking form, section 11 of Appendix 5. These examples are not exhaustive but give an idea of what may be expected within the case-notes.

# 5. EXAMPLES OF THE TYPE OF INFORMATION TO BE RECORDED

## 5.1 General features

5.1.1 Style and Legibility – Features which may be noted in this category relate to the general appearance, such as the "angularity", how "readable" the handwriting is etc. The lack of legibility, especially in signatures, is often encountered.



**Proposed wording:**
The signatures in Qn are legible and consist of disconnected lowercase letters, whereas the Kn, which have been produced over a wide time range and come from a variety of sources, consist of connected uppercase letters with limited legibility.

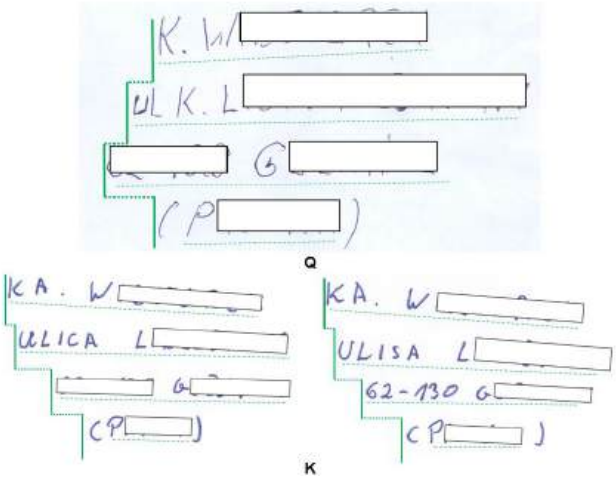
**Proposed assessment level:**

Style - -

Legibility -

Box 2 – Example of an assessment for level of similarity/difference for "Style" and "Legibility"

### 5.1.2 General Layout



**Proposed wording:** The left margin of the addressee data on the Qn envelope is irregular, and the baselines are ascending or horizontal. In contrast, the corresponding K samples have a widening left margin (each line of text starts slightly to the right relative to the previous one), and the baselines are clearly descending.

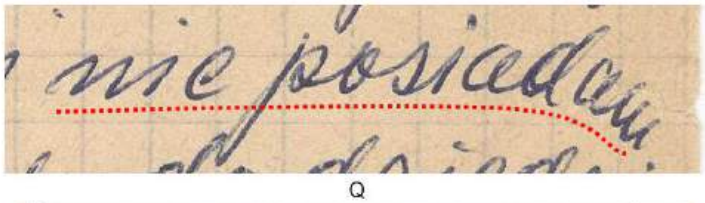
**Proposed assessment level:**

Left margin -

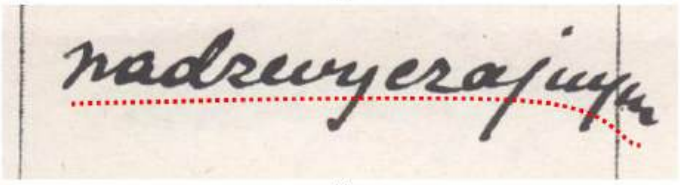
Baseline -

Box 3 – Example of an assessment for level of similarity/difference in general aspects of the "Layout"

5.1.3 Detailed layout features - Features such as the relationship between the size of the characters and the writing lines, occasionally the size of the paper may constrain the space for the handwriting and this may affect recognizable features.



Q



K

**Proposed wording:** In both Qn and K there are occasionally curved, descending baselines, which can be interpreted as the writer's reaction to limited space (whether by approaching the edge of a sheet of paper or crossing the boundary of the relevant form field).

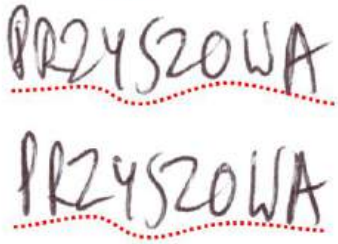
**Proposed assessment level:**

Layout +

Box 4 – Example of an assessment for level of similarity/difference in specific aspects of the “Layout”

5.1.4 Detailed baseline

Q



K

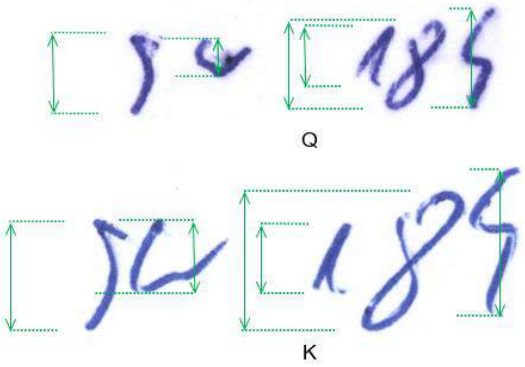
**Proposed wording:** The baselines of the word “PRZYSZOWA” present a similar wavy shape, with the bases of the letters “Y” and “S” positioned lower in relation to the adjacent characters.

**Proposed assessment level:**

Baseline +

Box 5 – Example of an assessment for level of similarity/difference in specific aspects of the “Detailed baseline”

5.1.5 Relative Size and Proportions - Relative size of letters in words, for instance a larger capital letter at the beginning of each word.



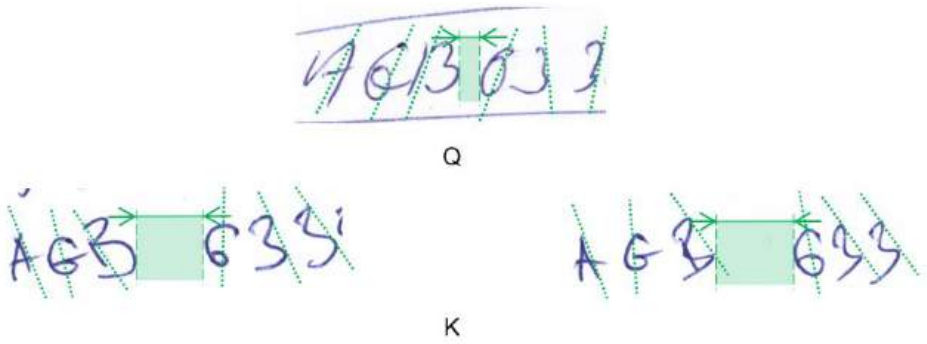

**Proposed wording:** The characters in the Qn are slightly smaller than the 20 relevant K samples. However, the relative proportions of a combination of characters in the Qn are well within the range of variability observed in K.

**Proposed assessment level:**

| | |
|---|---|
| Relative heights of Q v K | - |
| Relative proportions of characters | ++ |

Box 6 – Example of an assessment for level of similarity/difference for “Size of characters” and “Character Proportions”

5.1.6 Relative spacing and slope - Reference can be made to the relative spacing between individual characters, between words etc. as well as the upright, backward, forward or variable slant of the handwriting.




**Proposed wording:** The gap between the series and the number of the ID card is clearly and consistently larger in K than in Qn. Furthermore, characters in Qn generally lean to the right, whereas in K to the left.

**Proposed assessment level:**

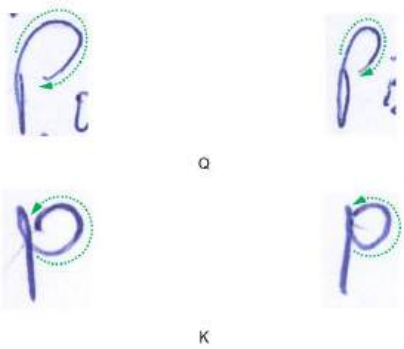
| | |
|---|---|
| Spacing | - - |
| Slope | - |

Box 7 – Example of an assessment for level of similarity/difference for “Spacing” and the “Slope”

## 5.2 Detailed features

### 5.2.1 Pen path and character construction

A

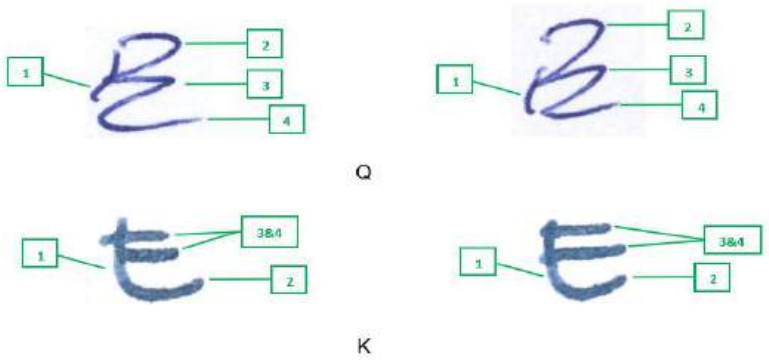



**Proposed wording:** The oval part of the letter "P" was produced clockwise in Qn, while counterclockwise in K.

**Proposed assessment level:**

Pen direction - -

B




**Proposed wording:** The order in which the strokes in the letter "E" are produced differs in Qn and K. In the former, the three horizontal strokes were made from top to bottom, as can be seen from their connections, whereas in K the bottom one was made immediately after the vertical stem.

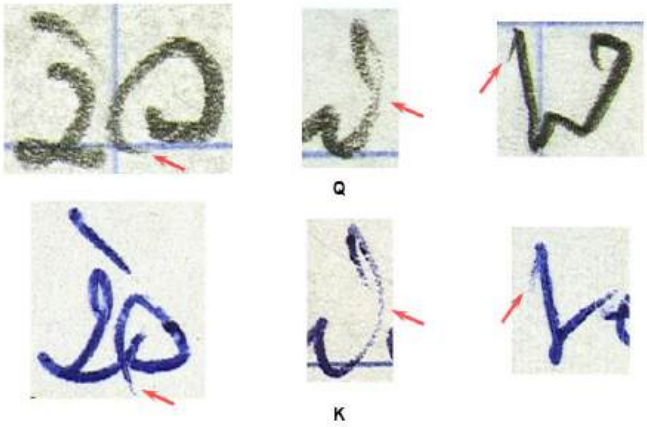
**Proposed assessment level:**

Sequence of strokes - -

Box 8 – Example of an assessment for level of similarity/difference in aspects of the “pen direction” [A] and “character construction” [B]

5.2.3 Fluency/Pressure - Reference can be made to whether the writing appears to be skilfully or poorly produced, whether there is hesitation in the pen line (pen lifts, tremor etc.), whether the writing line is smooth flowing and whether the writing line has variable pressure, or constant, hard pressure. Three main elements of fluency are connective strokes between characters, tapered ends within characters and variation in pressure within the writing and these are all considered during the comparison phase.

### 5.2.3.1 *Tapering features*



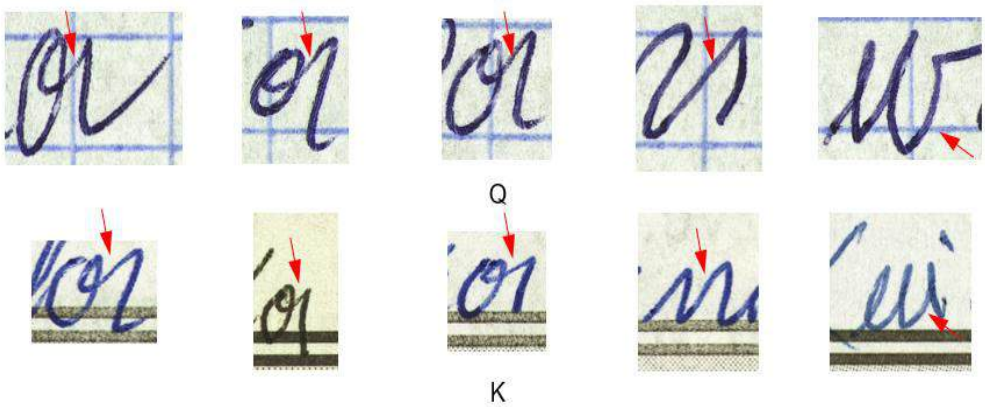

**Proposed wording:** Similar fluency/line quality was observed between Qn and K, which manifests itself in the tapering of the initial and final strokes, as well as the flying strokes in the connections between letter elements. These phenomena occurred even though different types of writing implements were used to produce the compared samples.

**Proposed assessment level:**

Tapered ends ++

Box 9 – Example of an assessment for level of similarity/difference for the “Tapering features”

### 5.2.3.2 *Variation in pressure and connectivity*



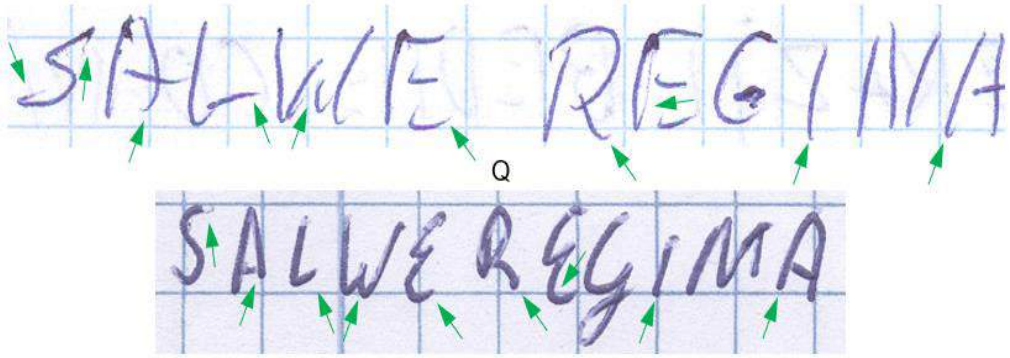

**Proposed wording:** Both Qn and K show rhythmic pressure, with its consistent shading/fluctuation within particular characters. For example, the connection between the oval and the final stroke in the letter 'a' or the ascending strokes in the letters 'n' and 'w' were produced with less pressure than their neighbouring parts.

**Proposed assessment level:**

Variable pressure ++

Box 10 – Example of an assessment for level of similarity/difference in both the variation in the “Pressure” and the “Degree of connectivity”

5.2.3.3 *Overall assessment of fluency (including variable pressure, connectivity and tapering)*




**Proposed wording:** Qn contains numerous tapered beginnings and endings as well as flying strokes, while the start and end points in K are generally blunt and shading/pressure fluctuations are negligible. Examples of corresponding parts of the Qn and K samples that exhibit different phenomena are marked with arrows.

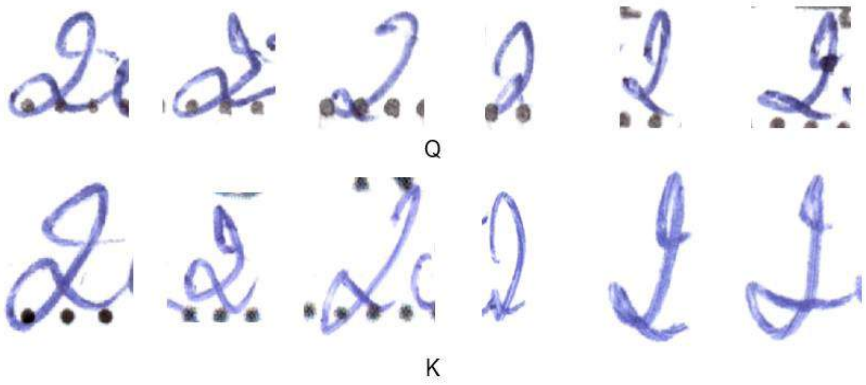
**Proposed assessment level:**

Overall fluency - -

Box 11 – Example of an assessment for level of similarity/difference in the overall “Fluency”

5.2.4 Range of variation – Reference can be made as to whether there is a wide range of variation within the material and how similar the ranges are between the Qn and Kn material

5.2.4.1 *Range of variation - similar*



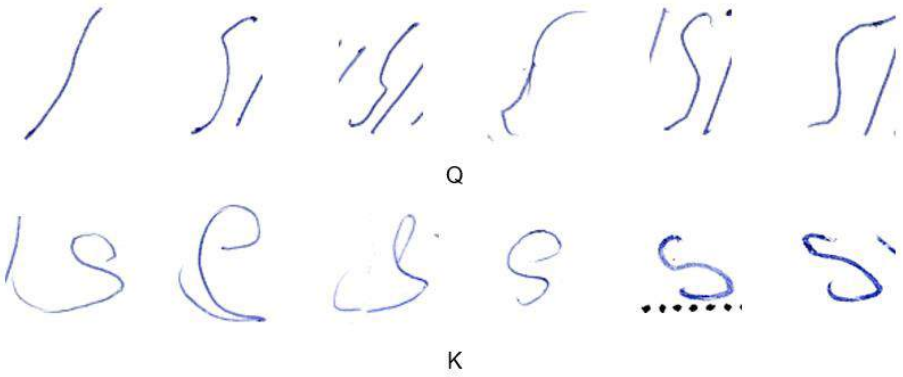

**Proposed wording:** Different representations of the numeral "2" exhibit a similarly shaped loop at the base in Qn and K, the top of the character is arched or obliquely flattened and in one variant also contains a loop.

**Proposed assessment level:**

Range of variation ++

Box 12 – Example of an assessment for level of similarity/difference in specific aspects of the “Range of variation” where the range is similar between Qn and Kn

### 5.2.4.2 *Range of variation – different (and wide ranging)*



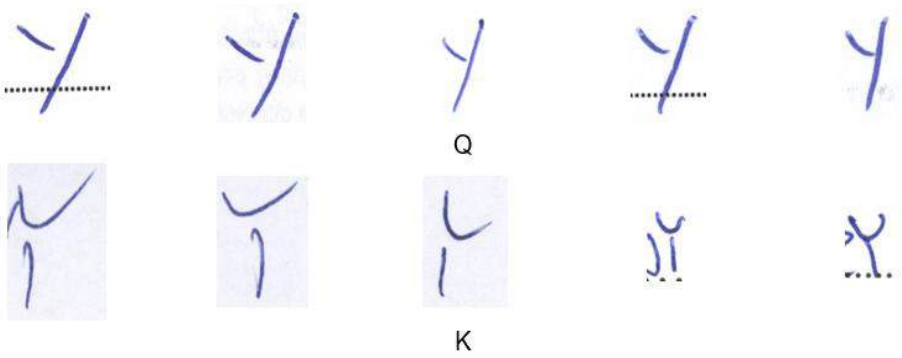

**Proposed wording:** In spite of the low stability of the structure of the letter "S", which presents a considerable range of variation in both materials, it was observed that in Qn it is generally weakly profiled, while in K the character is strongly curved.

**Proposed assessment level:**

Range of variation -

Box 13 – Example of an assessment for level of similarity/difference in specific aspects of the "Range of variation" where the range is quite wide but characters are different

### 5.2.4.3 *Range of variation – different (but relatively narrow)*



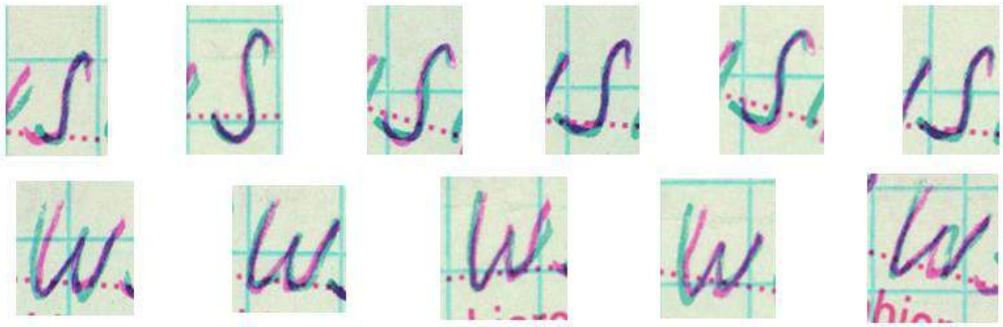

**Proposed wording:** In both Qn and Kn, the structure of the letter 'Y' is stable but different, since in the former case it consists of two diagonal lines, a shorter one on the left and a longer one on the right, while in K it is composed of an arc at the top and a short vertical line at the bottom.

**Proposed assessment level:**

Range of variation - -

Box 14 – Example of an assessment for level of similarity/difference in specific aspects of the "Range of variation" where the range is narrow for both Qn and Kn but different

5.2.4.4 *Superimposition*



**Proposed wording:** The shapes of the letters in the Qn and Kn are nearly identical and almost perfectly overlapping when superimposed.

**Proposed assessment level:**

Level of superimposition +

Box 15 – Example of an assessment for level of similarity/difference when aspect of the handwriting are superimposable

# 6. COMMUNICATION OF FINDINGS IN EXPERT REPORTS

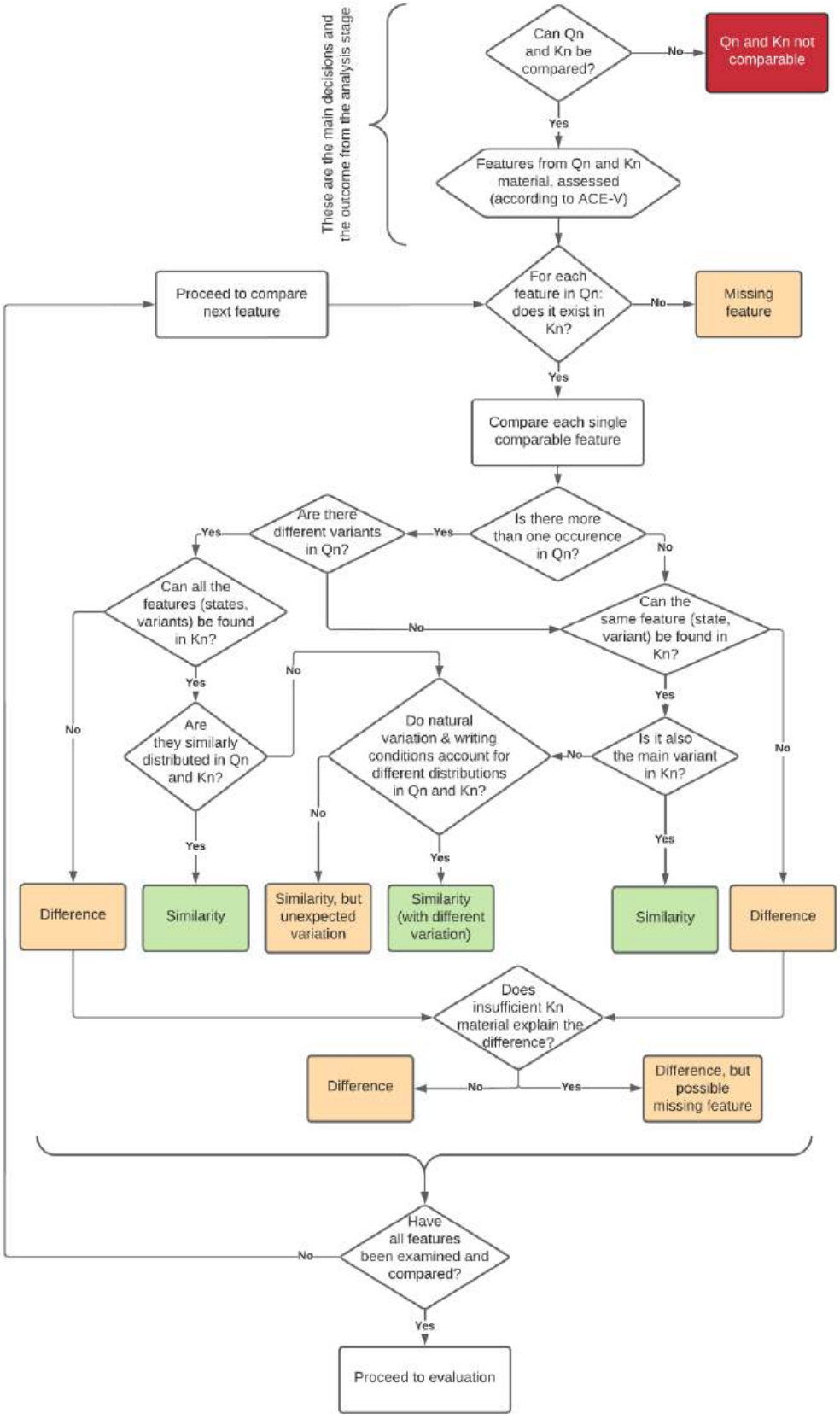
6.1 Traceability is an important requirement for an expert report, i.e. the examination and the findings thereof should be described in such a way that they are comprehensible to a lay person.

6.2 To achieve this, it is recommended that the findings from the comparison phase are described and documented in a separate section of the report, containing short descriptions of characteristics for the questioned and the known material as well as the findings from the comparison (similar or different). To obey the principle of proportionality, the findings documented in the report can be limited to a representative number of (key) characteristics. The interpretation of the findings (i.e. whether they support the proposition of same writer or that of different writer) should not be given in this section, but should be addressed in the following report section “evaluation of the findings”.

6.3 Characteristics can be described or documented using images, which can improve the comprehensibility to lay persons. The images may include annotations (numbers, lines, arrows, frames) as well as corresponding legends to highlight specific handwriting characteristics.

6.4 Attention should be paid to a balanced choice of the description and illustration of characteristics, to avoid creating the impression of partiality and to demonstrate that all features have been fully examined.

# 7. FLOW CHART OF THE COMPARISON PROCESS



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# APPENDIX 5 – EVALUATION

## 1. INTRODUCTION

1.1 It is recognised that within the reporting process for forensic handwriting examination there are a number of approaches to formulating a conclusion. Some of these are discussed within this appendix.

1.2 Evaluation, within the framework of the handwriting examination process (processes such as ACE, ACE-V or double ACE), is the third phase of examination. It is also the final step of the procedure undertaken by the examiner. Strictly speaking, it follows after both the questioned material (Qn) and the known material (Kn) have been analysed as well as systematically and fully compared. In practice evaluation of the findings is, to some degree, done in parallel to the first two phases. Nevertheless, seeing evaluation as a separate process helps in avoiding certain types of bias (especially circular reasoning).

1.3 According to the ENFSI Guideline for Evaluative Reporting in Forensic Science (ENFSI, 2015) an evaluative report is any report containing an evaluative reporting section which provides an assessment of the strength of the findings in the context of a given analysis. This approach is also detailed in other recent reports (NIFS, 2017; NIST 2020).

1.4 To prepare an evaluative report the forensic practitioner needs to understand factors such as:

- the use of probability as a measure of uncertainty,
- formulation of propositions,
- Bayesian framework,
- likelihood ratio,
- considering relevant context information.

1.5 There are three main principles that need to be considered when evaluating findings in a forensic handwriting examination:

- The framework of circumstances and any information relevant to the examination.
- At least two competing propositions (hypotheses).
- The probability of the evidence given the propositions and the framework of circumstances, which does not correspond to the probability of a proposition.

## 2. SCOPE

2.1 This appendix expands on the ENFSI Guideline for Evaluative Reporting in Forensic Science which does not contain an example of handwriting analysis. It presents the Forensic Handwriting Examiner with a practical approach to the evaluative reporting process within handwriting and signature examinations.

Using this approach might help Forensic Handwriting Examiners to develop a logical and scientific method to assess their findings.

2.2 The aim of the evaluation phase of the handwriting examination process is to systematically assess all of the findings as a whole given the competing propositions (hypotheses) in question, in such a way that a value of the evidential strength is obtained.

2.3 It is necessary to assign a probability (or likelihood of occurrence) of the findings under each of the propositions in question. The ratio between these probabilities gives the likelihood ratio, which represents the strength of the evidence. This can be communicated either in the form of a numerical value, or by using a verbal equivalent based on a verbal scale (or both). The application of this logical reasoning to traditional conclusion scales will also be addressed.

# 3. PROCESS FOR THE EVALUATION OF THE FINDINGS FROM A HANDWRITING COMPARISON

3.1 An overview of the evaluation process is represented in the flow chart in section 10. The flow chart includes the formation of the propositions, pre-assessment as well as the evaluation of the findings to reach a conclusion.

# 4. PROPOSITIONS / HYPOTHESES

## 4.1 General considerations

4.1.1 Any evaluation of scientific findings from an analysis and comparison of handwriting requires that at least two competing propositions are considered.

4.1.2 It has been suggested that the propositions can be classified into a “Hierarchy of propositions” (ENFSI, 2015, section 4.0; Cook and Evett, 1998) where Level I is “Source” level, Level II is “Activity” level and Level III is “Offence” level. This Appendix only deals with activity and source levels, as the offence level (for example “Mr. A committed the fraud” vs. “Another person committed the fraud”) is the reserve of the court.

4.1.3 In forensic handwriting cases, propositions on the activity and source levels are often interchangeable. Subtle differences could be introduced in the phrasing: while the pair of propositions “Mr. A wrote the questioned text” vs. “Another unknown person wrote the questioned text” describe an activity, “The questioned text was written by the same person as the reference material (purported to originate from Mr. A)” vs. “The questioned text was written by a different (unknown) person than the reference material” refer to a source. The latter formulations could be especially useful in cases where the examiner cannot be absolutely sure of the source of the reference material.

4.1.4. There is a number of potential sources for the propositions. These include;

- The propositions may be given by the submitting authority.

- The propositions may be established directly from the examination request question(s).
- The propositions may be derived indirectly from the written request or from the case circumstances and/or background information.

4.1.5 The propositions are usually developed when the examination request is received, i.e., before the examinations are undertaken, it is preferable that they are recorded at that point.

4.1.6 It is recommended that the propositions are documented in the report.

4.1.7 For a meaningful evaluation, the propositions must be mutually exclusive (i.e. they cannot both be true at the same time). While they are not required to be exhaustive, they should take into account all reasonable scenarios, including, where applicable any scenario put forward by other involved parties.

4.1.8 Routinely a case will contain two competing propositions, although in certain circumstances a case will require a greater number.

4.1.9 Propositions should not contain specific explanations of the findings under the proposition in question, such as “it is a perfect forgery” or “it was written by person A with the intent of disguise using the left hand”. Such explanations should be considered during the discussion of the findings under each proposition, but including them in the propositions might lead to an evidential strength of no value.

## 4.2 Setting the propositions

4.2.1 Two proposition scenarios

4.2.1.1 Potentially the most straightforward case derives from questions of the type “Did person A write the questioned text/signature?”. Routinely this leads to propositions of the type:

- “Person A wrote the questioned text/signature” (same source proposition) vs. “An unknown person wrote the questioned text/signature” (different source proposition).

4.2.1.2 In certain circumstances, the question asked is in the form of “Did person A or person B write it?”. In this case only a limited subset of the population should be considered. In such cases the examiner should ensure with the submitting authority whether or not it can be assumed that the document can only have been written by one of these two persons. This would lead to the following pair of propositions:

- “Person A wrote the questioned entry” vs. “Person B wrote the questioned entry”.

4.2.2 Multiple propositions and more complex scenarios

4.2.2.1 Multiple propositions are possible (e.g. “person A wrote it”, “person B wrote it” and “someone other than person A and person B wrote it”). Strictly speaking, in those cases an evidential value has to be evaluated for each pair of

propositions however it is recommended to only give one combined conclusion when reporting these results (i.e. “person A wrote the questioned text” versus “Person B or someone else wrote the questioned text/signature”; Robertson 2016, chapter 3.3).

4.2.2.2 Sub-propositions may need to be considered, for example if a potentially simulated signature needs to be compared to the known writing of a suspected simulator, and these can be worded using the following type of phrases:

- Questions raised: 1. Is the questioned signature genuine or simulated? 2. If it is simulated, was it written by person B?:
  - $H_1$: The questioned signature is genuine, i.e. it was written by person A.
  - $H_2$: The questioned signature is simulated, i.e. it was written by another person than A.
  - $H_{2a}$: The questioned signature was written by person B.
  - $H_{2b}$: The questioned signature was written by an unknown person other than person B.

If multiple sub-propositions are to be considered, the examiner would firstly reach a conclusion for $H_1$ versus $H_2$. If $H_1$ is supported over $H_2$, the sub-propositions usually become meaningless. If the findings provide support for $H_2$ over $H_1$ then the examiner would have to assess the likelihood ratio for $H_{2a}$ against $H_{2b}$.

# 5. PRE-ASSESSMENT

## 5.1 Goals and requirements of a case pre-assessment

5.1.1 A case pre-assessment helps the examiners in setting their expectations. It should be undertaken after the propositions have been stated based on the mandate and prior to starting the examinations. To perform a case pre-assessment, the examiner needs to be aware of the amount of the submitted material, as well as gaining a first impression of the extent and complexity of the questioned handwriting entries. Particular case circumstances might need to be considered as well.

5.1.2 Taking into account a pair of propositions, the examiner can now assess the probabilities of the possible likely outcomes (see boxes 1 and 2 as well as section 5.2).

5.1.3 Depending on the expected likelihood ratios, the examiner may report to the mandating authority if the examinations will be helpful in answering the relevant questions and discuss further progress (type of examinations to perform, possible reformulation of mandate questions, etc.). At that point, the examiner may advise that further steps need be taken before the examinations are performed, e.g. acquiring the original document or additional reference material.

## 5.2 Setting the expectations

5.2.1 The expectations for the examinations are set during the pre-assessment. Expectations are the possible outcomes of an examination (i.e. the

combination of similarities and differences observed), while the propositions refer to the potential scenarios in question.

In this example the questioned signature is short and of low complexity. The known material shows a small range of variation. No particular case circumstances are known. Based on the mandate questions, the examiner stipulates the following propositions:

- $H_1$: The questioned signature was written by Ms. A.
- $H_2$: The questioned signature was written by an unknown person other than Ms. A.

Under $H_1$ (i.e. if $H_1$ is true) the examiner would expect the questioned signature to show similarity in all features, possibly some smaller deviations in a limited number of characteristics. The probability of obtaining a large number of differences is estimated to be very small.
Under $H_2$ (i.e. if $H_2$ is true) some similarities can be expected due to the low complexity of the signature. In some cases, even a high degree of similarities could be expected. Finally, it is also perceivable that the questioned signature fully differ from the known signature in several characteristics.

These reflections could be formalized in a pre-assessment table as follows:

| **Outcome of the forensic handwriting comparison** | **Assigned probability of outcome assuming that the signature was written by Ms. A** | **Assigned probability of outcome assuming that the signature was written by an unknown person**[2] | **Likelihood ratio**[3] |
|---|---|---|---|
| Full similarity | Very high | Low | Moderate support for $H_1$ |
| Mostly similarity, some differences in shape | Low | Low | No support for either $H_1$ and $H_2$ |
| Similarity in shape, differences in dynamic handwriting features | Very low | High | Moderately strong support for $H_2$ |
| Clear differences | Very low | Medium | Moderately strong support for $H_2$ |

1 This reflects the conditional probability of the findings if $H_1$ is true, represented as $Pr(E|H_1)$. For these examples, verbal expressions (such as extremely low, very low, low, medium, high, very high, extremely high) for the assigned probabilities were used. Numerical probabilities can be used instead (taking care that the sum of the probabilities of the different outcomes under a given proposition equals 1).

2 This reflects the conditional probability of the findings if $H_2$ is true, represented as $Pr(E|H_2)$.

3 The likelihood ratio reflects the quotient $P(E|H_1) / P(E|H_2)$ in the Bayesian formula (see section 7.5.3). For these examples, verbal expressions taken from the ENFSI Guideline for Evaluative Reporting in Forensic Science (2015) for the assigned evidential strength (extremely strong support, very strong support, strong support, moderately strong support, moderate support, weak support, no support for either proposition). Numerical estimates can be used instead.

Box 1 - Example of a pre-assessment in a case involving a short, simple signature.

5.2.2 In the simple example shown in box 1 the expectations would be:

- For proposition $H_1$ the examiner would expect the questioned signature to show similarity in all features, possibly some smaller deviations in a limited number of characteristics.
- For proposition $H_2$ since the signature is a simple and short product, the examiner would expect that a certain number of similarities could be found. In some cases, even a high degree of similarities could be expected. Finally, there is a potential that the questioned signature fully differs from the known signatures in several features.

5.2.3 Based on the expectations for each proposition, possible likelihood ratios can be assigned for each possible outcome.

For a more complex signature, with limited known material, and a larger variation in the known material, different values would be assigned:

| **Outcome of the forensic handwriting comparison** | **Assigned probability of outcome assuming that the signature was written by Ms. A** | **Assigned probability of outcome assuming that the signature was not written by an unknown person** | **Likelihood ratio** |
|---|---|---|---|
| Full similarity | High | Extremely low | Strong support for $H_1$ |
| Mostly similarity, some differences in shape | Medium | Very low | Moderate support for $H_1$ |
| Similarity in shape, differences in dynamic handwriting features | Low | High | Moderately strong support for $H_2$ |
| Clear differences | Low (possible different variant due to the limited known material) | Medium | Weak support for $H_2$ |

Box 2 - Adjustments to the pre-assessment table when a more complex signature is to be examined.

# 6. ANALYSIS AND COMPARISON

6.1 A significant aspect of the handwriting examination process is the analysis and comparison aspects. These two parts of the examination are detailed in Appendices 3 and 6 (Analysis of handwriting and digitally captured handwriting respectively) and Appendix 4 (Comparison process).

# 7.1 EVALUATION OF THE FINDINGS

## 7.1 General

7.1.1 Evaluation of the findings of a handwriting comparison requires both the analysis and comparison stage to be completed and puts the integral findings into relation with the case framework (i.e. mandate question, propositions, relevant case circumstances). Evaluation requires a holistic approach, since one finding on its own cannot be interpreted properly (e.g. an unergonomic pen stop in the middle of a questioned signature cannot be interpreted without knowing the findings coming from other characteristics). Evaluation might take into account not only findings from the handwriting comparison, but also possible findings from electrostatic detection devices, spectral comparison techniques, and visual examination of the entire document.

7.1.2 It is good advice to start evaluation by reflecting (and documenting) on the most important findings (both similarities and differences) as well as factors that can influence the evaluation (e.g. complexity and variation of questioned and known material, amount of known material, relevant context information).

## 7.2 Relevant contextual information and context management

7.2.1 Relevant context information is any information provided by the mandating authority that is needed for the interpretation of the handwriting comparison findings. They provide possible explanations for discrepancies (e.g. purported particular writing conditions, health conditions of the writer, etc.) or for similarities (e.g. profession of the potential forger, access to model signatures, training opportunity for the potential forger, etc.). When taken into account, they may alter the assigned evidential strength in favour of either proposition. Their interpretation requires expert knowledge and is therefore within the competency of the forensic handwriting expert.

7.2.2 Any relevant context information that was considered during the examination should be stated within the expert report (ENFSI, 2015, section 5), either in a separate section (“Background information”), when stating the propositions or in the discussion of the findings.

7.2.3 If either the propositions or relevant background information change, the conclusions of the expert report may need to be reviewed. This should be stated in the report (ENFSI, 2015 3.12).

7.2.4 Irrelevant context information is any information that is not necessary to assess the handwriting comparison findings, such as confessions, motives, findings from other forensic disciplines, witness statements etc. Such information is prone to cause undesirable contextual bias (Dror , Charlton and Péron, 2006) to the expert’s opinion and should therefore be ignored.

7.2.5 Context management is a process implemented in case handling to reduce contextual bias (Found and Ganas, 2013). This process might regulate information provided by the mandating authority either in verbal and/or written exchange, in the case file or even in the examined documents. According to the infrastructure of the laboratory, a case manager might be implemented in the process. The process should ensure that relevant context information is

passed to the examiner (or second examiner respectively) and irrelevant context information is removed.

### 7.3 Evaluation of the findings under $H_1$ (same source proposition, e.g. Ms A wrote the questioned text/signature.)

7.3.1 Evaluation of the findings under the same source proposition (usually $H_1$) requires the examiner to discuss the (subjective) probability of the findings, if the questioned writing was written by the same person as the known writings. Generally, one would expect mostly similarities or in other words, that the questioned writing lies within the variation observed in the known material.

7.3.2 If more differences (than expected) can be found, i.e. if the questioned signature lies outside of the variation of the known material, the examiner needs to consider if the differences can be explained by other circumstances. Questions to consider depend on the case circumstances and could be as follows:

- What is the (natural) variation of the writer based on the known material? Does the questioned writing lay within the variation?
- Is the known material representative of the handwriting of the reference writer? Could the differences be due to limited known material and thus underestimated natural variation?
- Could the differences be due to a variant not covered in the known material or poor comparability of the known material (e.g. due to a different writing style)? Could the differences have happened accidentally?
- Could they be explained by a time difference between questioned and known material?
- Do the differences span the entire signature/writing or are they only affecting part of the signature/writing?

7.3.3 In certain cases, relevant context information is available and needs to be considered, such as:

- If details about the poor health state of a person are known, could the differences be explained by the presumed illness (or age)?
- If particular writing circumstances are an option, could the differences be caused by them?
- If disguise is an option, could the differences be due to an attempted disguise? In which case, did the person have to produce disguise while other people were around and could the situation be anticipated?

Note, that depending on the known case circumstances not all of those questions need to be considered.

7.3.4 At the end of the argument, the examiner needs to make an assignment of the probability of the integral findings under the proposition $H_1$ (same source) based on the known case circumstances. The assignment of the probability may have changed from the one given in the pre-assessment based on the thorough examination. The assigned probabilities should be based on the

value of the combined findings (consider dependencies between similarly shaped signs), if available (statistical) research data[2] thereof, the amount and variation of the questioned material, the amount and variation of the known material, limitations due to the questioned or known material, knowledge on the influence of different factors on a person's handwriting, as well as the examiner's experience.

### 7.4 Evaluation of the findings under $H_2$ (different source proposition, e.g. Someone other than Ms A wrote the questioned text/signature.)

7.4.1 Evaluation of the findings under the different source proposition (usually $H_2$) requires the examiner to discuss the probability of the findings, given that the questioned writing was written by a different person than the known writing. Generally, one would expect differences of varying nature, depending on possible explanations for the findings that need to be taken into account. It is expected that the questioned writing lies outside of the variation observed in the known material.

7.4.2 If a certain degree of similarity can be found, under the different source proposition ($H_2$) one of the most obvious explanations would be a simulation of the questioned signature or of the questioned text. On the other hand, the possibility of a chance match needs to be discussed as well.

7.4.3 To assess if such possibilities are plausible explanations for the findings, a number of factors need to be considered:

- Can the degree of similarity be expected based on the length and complexity of the writing, due to an attempt of simulation? What is the ease of simulation of the signature (or text)? (Found, Rogers, Rowe and Dick, 1998)
- Could the similarities have occurred by chance between two persons (either purely accidentally or due to the use of a similar writing style based on a school model) and what is the probability of this happening to this particular degree?
- Are there indications (i.e. case circumstances) that suggest, that the two writers might have especially similar handwritings (e.g. same school, family relation)?
- Do the differences affect rather dynamic features or rather the shape of the writing?
- If a longer text or several signatures are questioned, do they show signs of natural variation?

7.4.4 In certain cases, relevant context information is available and needs to be considered, such as:

- Did the potential forger have the possibility to exercise the simulation?

2 Research on natural variation (intra variation) of a writer. Application of this knowledge to a particular case requires examination of the variation in the known material.

- Did the signature have to be produced in front of another person (imposed identity)?
- Was the potential forger able to anticipate that they would have to produce the simulation?
- Is it reasonable to assume that the potential forger had access to model signatures/texts?
- Is anything known about the graphical ability of the potential forger (adept penman)?

7.4.5 At the end of the argument, the examiner needs to make an assignment of the probability of the integral findings under the proposition $H_2$ (different source) based on the known case circumstances. The assignment of the probability may have changed from the one given in the pre-assessment based on the thorough examination. The assigned probabilities should be based on the value of the combined findings (consider dependencies between similarly shaped signs), if available (statistical) research[3] data thereof, the amount and variation of the questioned material, the amount and variation of the known material, limitations due to the questioned or known material, knowledge on the influence of different factors on a person's handwriting, as well as the examiner's experience.

## 7.5 Assessment of the likelihood ratio or verbal conclusion

7.5.1 The assigned probabilities (sections 7.3 and 7.4) are subjective, but informed estimations based on the best available knowledge of the examiner and a detailed examination/comparison of the Qn and Kn material. The probabilities should be of a verbal (descriptive) or numerical nature.

7.5.2 By dividing the assigned probabilities for both propositions, the examiner obtains a likelihood ratio, which is a logically sound way to express the evidential strength.

7.5.3 If verbal expressions are applied to communicate the strength of the evidence, they should strictly follow a fixed verbal scale, which should follow certain rules as explained in the ENFSI Guideline (2015). A verbal conclusion scale is basically an ordinal scale of evidential strength (Marquis, Biedermann, Cadola, et al. 2016).

7.5.4 Verbal expressions follow either of the following schemes:

- The findings [strongly] support $H_1$ over $H_2$.
- The findings provide [strong] support for $H_1$ over $H_2$.
- The findings are X times more probable if $H_1$ is true than if $H_2$ is true.

7.5.5 It is also possible to transform numerically assigned likelihood ratios to the verbal scale or to report both the numerical LR and the verbal equivalent.

3 Research on the frequency of certain characteristics in the population (inter variation; consider that such studies likely only apply to the region where it has been conducted), as well as research on characteristics appearing in simulations, complexity model.

7.5.6 The likelihood ratio or the verbal expression states an overall opinion of the examiner on the evidential strength.

## 7.6 Impact of the LR on the case

7.6.1 The Forensic Handwriting Examiner gives the strength of the evidence, in the light of a set of propositions. The examiner therefore deals with probability of the evidence given a proposition (in comparison with probability of the evidence given an alternative proposition).

7.6.2 Within this framework, it is not the role of the Forensic Handwriting Examiner to express an opinion about the probability of a proposition given the evidence (for example: It is highly probable that Person A wrote the questioned writing). This is called a posterior probability. Posterior in the sense that it represents the updated probability of a proposition, by taking into account not only the prior probabilities (see 7.5.4), but also the forensic evidence provided in the form of a LR by the scientist.

7.6.3 The framework to obtain posterior probabilities is defined by the Bayesian formula in the odds form, according to which the likelihood ratio (i.e., the evidential strength; as obtained in section 3.3.4) combined with the ratio of the prior probabilities result in the ratio of the posterior probabilities:

$$\frac{Pr(E|H_1,I)}{Pr(E|H_2,I)} \cdot \frac{Pr(H_1|I)}{Pr(H_2|I)} = \frac{Pr(H_1|E,I)}{Pr(H_2|E,I)}$$

Likelihood Ratio · Prior odds = Posterior odds

7.6.4 Prior probabilities of the propositions generally depend on knowledge of case circumstances, witness statements, and other forensic evidence not known to the handwriting examiner. Assessing the prior probabilities is therefore not the task of the examiner, but lies within the competency of the court.

## 7.7 Traditional conclusion scales

7.7.1 Traditional scales of conclusions or opinions are still widely used in certain legal frameworks and laboratory practices. By traditional conclusion scales, we mean statements, which include posterior probabilities, such as “It is highly probable that Person A wrote the questioned writing”. They state probabilities of the propositions given the findings (of the handwriting examination) and not, as expressed in the Likelihood Ratio, the probabilities of the findings given the propositions.

7.7.2 According to Bayesian formula (7.6.3) prior probabilities need to be known to be able to state posterior probabilities. Assessing the prior probabilities is not the task of the examiner, since this requires knowledge of case circumstances, witness statements, and other forensic evidence (cf.7.6.4).

7.7.3 Commonly used and described in the literature is an approach describing how to state posterior probabilities in absence of the required knowledge of case circumstances. In this approach prior probabilities need to be assumed. A

common way to do this, is by assuming the prior probabilities for all propositions to be equal (Köller et al., 2004). If this approach is used it is recommended to clearly and explicitly state this assumption of the prior probabilities in the report.

7.7.4 Where possible, use of logical reasoning is encouraged, and even when traditional scales are required, they should be used separately and based on logical reasoning with the further explanation of their scientific limitations.

### 7.8 Comment on certainty conclusions

7.8.1 Absolute conclusions are conclusions which exclude all the alternative propositions but one. Thus, a positive absolute conclusion is the identification (or individualisation) of a person as the writer of a questioned writing to the exclusion of all others. A negative absolute conclusion is the exclusion of a person as the writer of a questioned writing.

7.8.2 In general cases, absolute conclusions cannot be justified scientifically. If identifications are stated in a conclusion, this statement remains the personal opinion/conviction of the reporting examiner.

7.8.3 If absolute conclusions (especially identifications) are required by the legal system, the report should include information about scientific limitations of the method and state the conclusion in form of an opinion.

### 7.9 Documentation of the evaluation process

7.9.1 Clear and precise notes assist in rendering the evaluation process more transparent (ENFSI 2015, sections 3.11 and 4.0). The evaluation process should be well documented in both the case notes as well as in the report. It is possible to use predefined forms (see section 11), where the relevant questions need to be answered/assessed e.g. by filling in the information, by using checking boxes, or by taking text notes on the evaluation process.

## 8. REPORTING THE RESULTS

8.1. Expert reports are required to follow accreditation instructions of the individual laboratories.

8.2 Short report formats (e.g. investigative reports, preliminary reports, police reports), which do not fulfil all requirements of an expert report, are acceptable where required and in accordance with local regulations. In such a report format, it should be clearly stated that this is not a formal expert report.

8.3 The following recommendations may assist to implement the evaluation process to expert reports:

- The mandate questions and the propositions on which the evaluation is based should be explicitly stated (see section 2.1).
- Relevant case circumstances and background information considered during the examination should be disclosed.

- The applied conclusion scale should be included (e.g. in the methods section of the report).
- There should be separate sections/paragraphs on the findings of the examination (i.e. which features are similar/dissimilar) and the evaluation of the findings with regards to the propositions in question.
- This section can be titled e.g. “Evaluation of the findings” or “Discussion of the findings”.
- The plausibility of the entire findings under each proposition should be discussed, including any findings which might weaken the conclusion.
- At the end of the discussion of the findings, the conclusion should be stated according to the conclusion scale applied.
- A separate section should summarize the conclusions, answering the mandate questions. Usually this is the final section titled “Conclusions”.
- A statement that if either the propositions or the background information change, the conclusions of the expert report may be required to be reviewed should be included.

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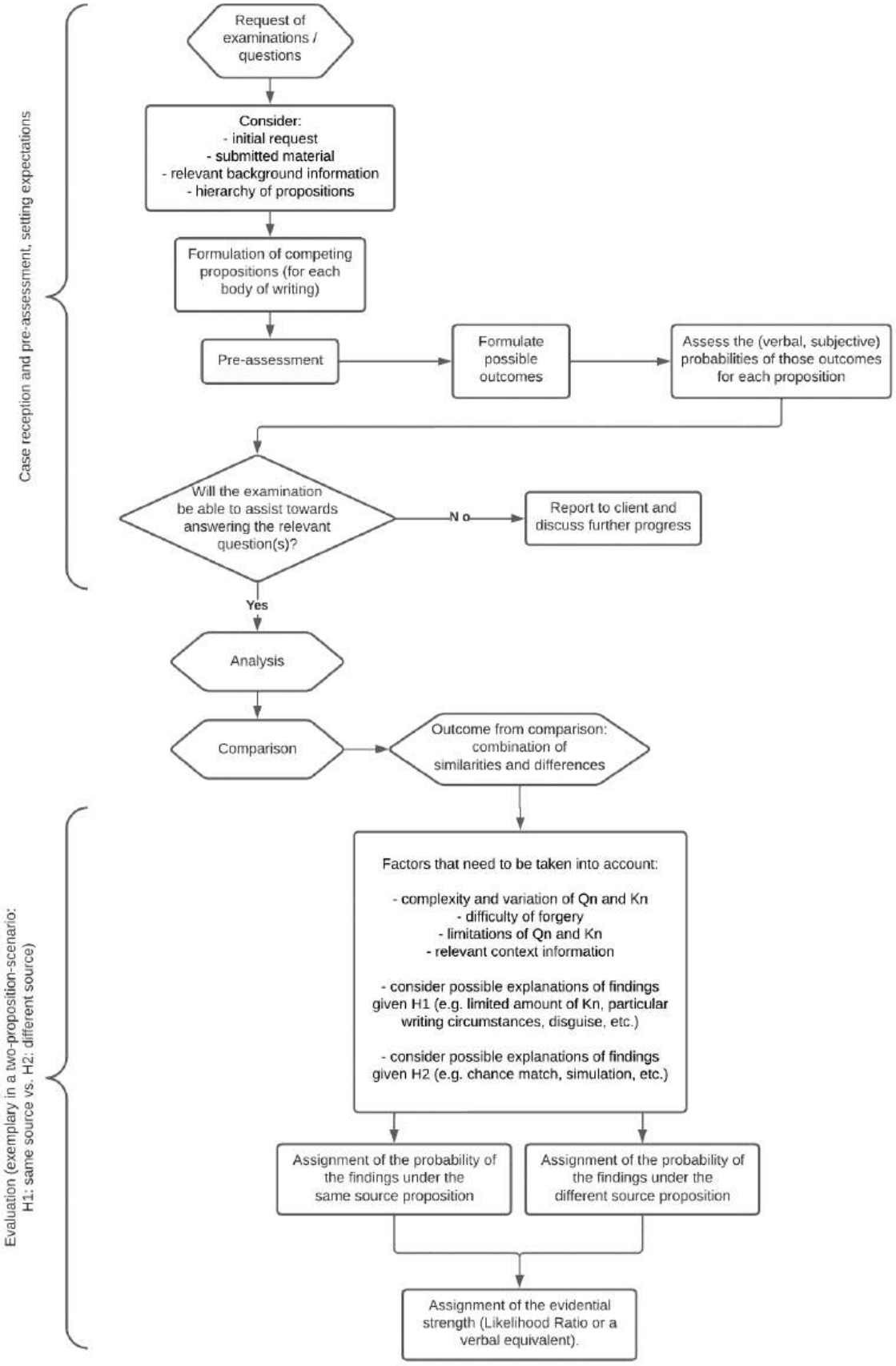
# 10. FLOW CHART OF THE EVALUATION PROCESS



# 11. NOTETAKING FORMS

11.1 The following form for notetaking (see subsequent pages) is illustrative, does not include all of the relevant information and is principally based on an Evaluative Reporting approach. If the FHE or organisation does not use Evaluative Reporting the relevant boxes can be replaced or omitted. If the questioned or reference samples are not homogenous they should be divided into consistent parts and this form should be completed for each comparison and evaluation. The forms can be either printed and filled by hand or edited. The forms should be edited/adapted to meet the requirements of the Laboratory's management system.

| LABORATORY LOGO | LABORATORY NAME AND CONTACT DETAILS | Laboratory Form Identification No. |
|---|---|---|
| | | Lab. Case Reference No. |
| Type of examination | | |
| 1st examiner/date | | |
| 2nd examiner/date | | |

# Section 1 – General Case Information

| | | |
|---|---|---|
| **Requested question** | | |
| | | |
| **Material** | | |
| **Questioned writing (Qn)** | | |
| **Consistency of Questioned writing** | | |
| **Reference material** | **Collected (source: court, police):** | |
| | **Requested specimen (source: personal, official):** | |
| **Consistency of reference material** | | |
| **Comments** | | |
| | | |
| **Background information** | | |
| **Details related to the person examined** | **Detail/source** | **Not known (x)** |
| Age at the time when the questioned writing is assumed to have been produced | | |
| Illness/accident/medication/alcohol/drug | | |
| Foreign origin | | |
| **Other details** | **Detail/source** | **Not known (x)** |
| Situation/circumstances of writing (e.g. unusual position or writing surface) | | |
| Others | | |
| | | |
| **Proposition/Hypotheses** | | |
| Main proposition ($H_1$) | | |
| Alternative proposition ($H_2$) | | |

| LABORATORY LOGO | LABORATORY NAME AND CONTACT DETAILS | Laboratory Form Identification No. |
|---|---|---|
| | | Lab. Case Reference No. |
| Type of examination | | |
| 1st examiner/date | | |
| 2nd examiner/date | | |

| **Sub-proposition (if relevant)** | |
|---|---|
| $H_{1A}$ | |
| $H_{1B}$ | |
| $H_{2A}$ | |
| $H_{2B}$ | |

| **Expectations** | |
|---|---|

| **Factors affecting the quality, sufficiency and comparability of the examination material** | **Questioned sample (samples (no.)/observation)** | **Reference sample (samples (no.)/observation)** |
|---|---|---|
| Sample is an original/copy | | |
| Sufficiency of quantity of writing | | |
| Type of writing | | |
| Time of writing | | |
| Writing implement | | |
| Others | | |

| **Overall evaluation of how well the examination material is suited for the examination** | **Sufficient (x)** | **Limited (x)** | **Inadequate / examination cannot be performed (x)** | **Comment (if needed)** |
|---|---|---|---|---|
| | | | | |

| **Measure** | **Yes (x)** | **No (x)** | **Comments/observations** |
|---|---|---|---|
| Samples scanned | | | |
| Samples viewed under microscope | | | |
| Samples photographed using microscope camera | | | |
| Oblique lighting | | | |
| Indented writing | | | |
| Video spectral equipment | | | |
| Others | | | |

**General comments:**

| LABORATORY LOGO | LABORATORY NAME AND CONTACT DETAILS | Laboratory Form Identification No.<br>Lab. Case Reference No. |
|---|---|---|
| Type of examination | | |
| 1st examiner/date | | |
| 2nd examiner/date | | |

# Section 2 – Examination Results

| General examination | | | |
|---|---|---|---|
| **General features (Appendix 3-BPM)** | **Questioned sample(comment/observation if needed)** | **Reference sample (comment/observation if needed)** | **Assessment[1]** |
| Style and legibility | | | |
| Size | | | |
| Proportions | | | |
| Spacing | | | |
| Slope | | | |
| Fluency/Pressure | | | |
| Line quality | | | |
| Layout | | | |
| Other | | | |

| **Detailed examination: Handwriting compared and the shapes, formations and proportions of the handwriting details.** | | |
|---|---|---|
| **Questioned sample** | | |
| Sample (no.) | Date[2] / other detail | **Note:** the material can be copied or drawn depending on the amount of signature/handwriting. The expert can add rows depending on the number of samples. |
| | | |
| | | |
| **Reference sample** | | |
| Sample (no.) | Date[2] / other detail | **Note:** the material can be copied or drawn depending on the amount of signature/handwriting. The expert can add rows depending on the number of samples. |
| | | |
| | | |

| **Letter shapes, formations and proportions, and shapes of liaisons between letters (if needed)** | | | |
|---|---|---|---|
| **Letter** | **Questioned sample** | **Reference sample** | **Assessment [1]** |
| | | | |
| | | | |
| | | | |
| | | | |

1 Symbols suggestion (other system can be used): ++ clearly similar, + similar, ~ inconclusive, - different, -- clearly different, **NC** examination not possible because a feature is missing in the known material or is not comparable.

2 Date on the sample, not necessarily the date of the signature.

| LABORATORY LOGO | LABORATORY NAME AND CONTACT DETAILS | Laboratory Form Identification No. |
|---|---|---|
| | | Lab. Case Reference No. |
| Type of examination | | |
| 1st examiner/date | | |
| 2nd examiner/date | | |

# Section 3 – Evaluation and Conclusion

| **Most significant findings** | **Description** | |
|---|---|---|
| Similarities | | |
| Differences | | |
| | | |
| **Evaluation under H1** | | |
| **Do the findings correspond to the expectations in handwriting from the same person?** | **Yes (x) / comment** | **No (x) / comment** |
| | | |
| **Can the differences be explained due to:** | **Yes (x) / comment** | **No (x) / comment** |
| natural variation? | | |
| particular writing conditions (e.g. unusual position or writing surface)? | | |
| age, illness, accident, medication, alcohol, drugs? | | |
| disguise? | | |
| other explanations? | | |
| **Comments** | | |
| **Evaluation under H2** | | |
| **Do the findings correspond to the expectations in handwriting from different persons?** | **Yes (x) / comment** | **No (x) / comment** |
| | | |
| **Can the similarities be explained by:** | **Yes (x) / comment** | **No (x) / comment** |
| chance match? | | |
| simulation? | | |
| tracing? | | |
| other explanations? | | |
| **Comments** | | |
| | | |
| **Overall evaluation of findings under H1** | | |
| | | |
| **Overall evaluation of findings under H2** | | |
| **Summary/other points** | | |
| **Conclusion**[3] | | |

3 Scale of conclusion. It´s advisable to have your conclusion scale definition printed in the forms to facilitate the work of the experts.

| LABORATORY LOGO | LABORATORY NAME AND CONTACT DETAILS | Laboratory Form Identification No. |
|---|---|---|
| | | Lab. Case Reference No. |
| Type of examination | | |
| 1st examiner/date | | |
| 2nd examiner/date | | |

## Section 4 – Peer review phase

| | | | |
|---|---|---|---|
| **Conclusion** | | | |
| | | | |
| **Conclusion 2nd examiner** | | | |
| | | | |
| **Conclusion discussion** | Date | Comments | No discussion(x) |
| | | | |
| **Content of discussion and grounds for decision** | | | |
| | | | |
| **Final conclusion / other result if different from the conclusion of the first examiner** | | | |

# APPENDIX 6 – OVERVIEW PROCEDURE FOR FORENSIC EXAMINATIONS AND COMPARISONS OF DIGITALLY CAPTURED SIGNATURES AND HANDWRITTEN ENTRIES

## 1. INTRODUCTION

1.1 This Appendix refers specifically to the examination of both Digitally Captured Signatures (DCSs) and Digitally Captured Handwritten Entries (DCHs). However, since the data of DCSs and DCHs can be treated alike and given that the latter are uncommon, only the acronym “DCSs” (or “DCS” in singular) will be used in this Appendix for reasons of clarity.

1.2 The purpose of the examination is to determine whether or not there is evidence that two or more pieces of handwriting, which include at least one DCS, have a common authorship. The approach relies on a visual analysis, a comparison of the characteristics of the DCSs and an assessment of the similarities and differences of both their static and dynamic characteristics. The numerical data of DCSs facilitates the calculation of features and the performance of statistical analysis which can also be a part of the examination.

1.3 The forensic handwriting examination of DCSs as opposed to conventional pen and paper handwriting and signatures (which is specified in Appendix 3 of this BPM) requires a modification of several aspects. These are detailed in this Appendix.

## *2.* SCOPE

2.1 The scope of this procedure covers the forensic examination and comparison of DCSs, as well as conventional handwriting and signatures. This addresses three different (but not mutually exclusive) combinations:

- questioned DCS(s) vs reference DCS(s),
- questioned DCS(s) vs reference conventional handwriting and signature(s),
- questioned conventional handwriting and signature(s) vs reference DCS(s).

## 3. PRINCIPLES

3.1 The principles, stated in section 3 of Appendix 3, also apply to the examination of DCSs.

3.2 The outcome of an examination of a questioned DCS is a conclusion relating to the question of whether an individual wrote a particular signature. While the examiner has to take into account possible limitations regarding the integrity of a signed “electronic document”, its determination goes beyond the scope of this BPM. This responsibility resides with the field of forensic IT (see section 9.7 “Limitations concerning the conclusions in DCS examination cases”).

# 4. HEALTH AND SAFETY

4.1 There are no specific health hazards or contamination risks when handling DCSs.

4.2 The risks in handling conventional documents, that might concern DCSs as well, are detailed in section 14 of the BPM and section 4 of the related Appendix 3.

# 5. TERMS AND DEFINITIONS

5.1 For Terms and Definitions related to forensic handwriting examination in general see Appendix 4. The following Terms and Definitions are related to DCSs.

## 5.2 Definition of a DCS

5.2.1 A DCS is a handwritten signature which is digitized during its production. Even though both DCSs and conventional handwriting and signatures are products of writing behaviour, a DCS is capable of containing more information, such as spatial coordinates, time and pressure[4] values.

5.2.2 A DCS is commonly referred to in a number of ways, such as:

- biodynamic signature,
- biometric signature,
- digital handwritten signature,
- dynamic signature,
- handwritten electronic signature,
- online signature.

Note that some of these terms are similar to the legal term “electronic signature”, which is more general, or the commonly used term “digital signature”, that does not refer to handwriting at all (see paragraph 5.2.3).

5.2.3 Sometimes the terms “electronic signature” or “digital signature” are used to refer to a DCS. However, “electronic signature” is a legal term[5] that relates to all kinds of electronic data, which is logically associated with other data in electronic form and used by a signatory to sign. Thus, the term “electronic signature” is more general and includes not only DCS, but also other forms of signatures, such as a scan of a conventional signature or a typed name at the end of an e-mail. The term “digital signature”, although it may seem to be a synonym for the term “electronic signature”, typically refers to cryptographic mechanism often used to implement electronic signatures.

5.2.4 A DCS is produced using a digitizing device, such as a signature pad, tablet or smartphone, together with capturing software. Both components – hardware

4 Some capturing devices record force values. However, the term “pressure” will be used as a synonym in this Appendix because it is a common term in forensic handwriting examination.

5 Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market.

and software – form a “DCS capturing solution”. In contrast to conventional handwriting or signatures (also known as offline handwriting/signatures), which may be scanned or photographed after their execution, DCSs are digitized during the writing process.

5.2.5 Static characteristics (image) as well as the dynamic characteristics, such as time related features (e.g. duration or velocity) and pressure, are essential for a forensic examination of a DCS.

## 5.3 DCS and the notion of original signature

5.3.1 For the examination of conventional handwriting and signatures, the original document (if available) should be examined to avoid loss of information. An original handwriting/signature is the trace of a writing material (e.g. ink) made on a substrate, typically paper. According to the principles detailed in paragraph 3.1.2 of Appendix 3, “no two naturally written signatures are exactly the same (assuming that a "signature" machine has not been used)”. In contrast a DCS, being digital data, is not permanently embedded in a particular substrate and can be incorporated in (or associated with) multiple electronic documents.

5.3.2 Whereas the reproduction process of conventional handwriting or signatures, e.g. by scanning or copying, leads to a loss of information, the digital multiplication of a digitally signed document retains the same DCS information. Against this backdrop, it is important, from a forensic point of view, to differentiate between the examination of genuineness and integrity. The examination of genuineness aims to determine “who made the signature” and resides in the field of forensic handwriting examination. However, the examination of the electronic document´s integrity, e.g. regarding possible alterations or assembly of a signature into another document, may be a part of other forensic disciplines, like forensic IT (see section 9.7 “Limitations concerning the conclusions in DCS examination cases”).

5.3.3 For security reasons, the capturing software usually embeds a DCS into an electronic document (e.g. a PDF) together with a digital signature (a non-handwritten, cryptography-based element, see paragraph 5.2.3). The digital signature should serve to prevent possible alterations of the document.

5.3.4 Typically, only an image of the DCS is shown in the signed PDF document which may contain modified signature characteristics (e.g. absolute and relative size, quality of the line, pressure etc.). Therefore, all characteristics of DCSs should be analysed using relevant software (see section 5.4).

5.3.5 Some capturing solutions only save an image of a DCS with no access to numerical data. Such a situation causes serious limitations to the forensic examination, since only a part of a DCS’s characteristics is available for analysis.

5.3.6 However, common solutions usually embed further DCS data in the PDF document, such as spatial coordinates, time and pressure values. This information is typically encrypted and made accessible only to a forensic

handwriting examiner (FHE). It is essential for examining important signature characteristics (especially dynamics, i.e. time related features).

## 5.4 Software

5.4.1 Three functions are important for DCS-related software: capturing, extraction and analysis of data. Some programs include only one of these functions, some more. Whereas DCS capturing software records data and stores it in an electronic document, another software may be used to extract signature information from a file for the purpose of forensic examination. The extraction may require a specific certificate and a key to decrypt the signature data. Analysis software allows to examine handwritten products by e.g. calculating local and global features, plotting graphs, making visualisations and animations, and often allows capturing reference DCS for a specific case. While some of these functions may be found in common data processing programs, analysis software dedicated to the examination of DCSs is often provided by companies that sell capturing tools and is usually made available to FHEs only. In most cases, it can only work with signatures that were captured with products from the same software manufacturer (see section 5.6.4).

5.4.2 Some analysis software may modify DCS data without explicitly informing the user. For example, the software may use smoothing algorithms for displaying graphs of pressure values. In these circumstances the FHE should be aware that a graph of the same data may look different in such a software, when compared to a graph generated by a processing software, like a spreadsheet application.

5.4.3 There is a significant difference between forensic analysis software that is aimed at supporting the examination of DCSs performed by a FHE on one hand, and software that serves for the automated authentication of a signatory (verification of identity) on the other. The former one helps a FHE to analyse, compare, illustrate and calculate features of DCSs. The latter is supposed to provide a function of “automatic verification of authenticity” of newly input signatures, on the basis of a comparison with previously enrolled (reference) signatures. Automatic verification is not, however, equivalent to a forensic evaluation process, because it compares limited number of features, and doesn’t take into account alternative propositions or any factors that may affect the signing process. Therefore, while automatic verification of DCS authenticity could principally be an additional tool for a user institution in its authentication policy, it cannot replace an experienced FHE in case work.

## 5.5 Numerical values

5.5.1 During the recording process of a DCS, a series of data points is captured. This data is the core information of the DCS and it allows to calculate various characteristics (such as duration, line/stroke length, velocity, acceleration) and to create different kinds of illustrations (see section 5.7 “Illustrations of DCSs” and figure 1). Typically, four data channels[6] are registered (tab. 1):

6 The international standard ISO/IEC 19794-7/Amd.1:2015, Information technology — Biometric data interchange formats — Part 7: Signature/sign time series data, uses the following channel names:

- *X-coordinates*
  These are the horizontal coordinates of the writing instrument's tip on the writing plane.
- *Y-coordinates*
  These are the vertical coordinates of the writing instrument's tip on the writing plane.
- *Pressure values*
  The magnitude of the pressure values/the pen tip force. The underlying principle of capturing the pressure or pen tip force differs between hardware products. The captured values are usually not given in IS units, such as newton or pascal.
- *Time stamp*
  The time elapsed since the first sample, usually recorded in milliseconds.

| Point (sampling moment) | X-coordinates | X-coordinates | Pressure values | Time stamp |
|---|---|---|---|---|
| **1** | 1108 | 580 | 338 | 0 |
| **2** | 1108 | 581 | 341 | 5 |
| **3** | 1110 | 584 | 340 | 10 |
| **4** | 1111 | 587 | 349 | 15 |
| **5** | 1113 | 590 | 348 | 20 |
| **6** | 1116 | 594 | 352 | 25 |

Tab 1. Example of DCS data

5.5.2 Some devices – especially tablets used by graphic artists or designers – may provide additional information, such as pen orientation (rotation and different angles).

## 5.6 File formats

5.6.1 Extracted numerical signature data can be saved, depending on the software used, in various file formats such as:

- CSV (comma separated values) or TSV (tab separated values) – the data of a sampling moment (X- and Y-coordinates, pressure and time stamps) is shown in one row and can be viewed in common text editors
- ISO formats (full format, compact format, compression format, XML) – as defined in ISO/IEC 19794-7:2014/Amd.1:2015
- Other conventional spreadsheet formats (i.e. XML) – readable with open source software
- Proprietary file formats – readable only with software created by a particular DCS capturing solution provider.

5.6.2 These files may also include metadata of a DCS.

X (x coordinate), Y (y coordinate), F (pen tip force), and T (time). The standard mentions in total 16 channels.

5.6.3 All known formats include the numerical values. However, these values may be stored in such a way that the coordinates are not directly readable (e.g. in hash values). CSV, TSV and sometimes XML files can be directly used in several data processing software, such as R, Excel or GnuPlot.

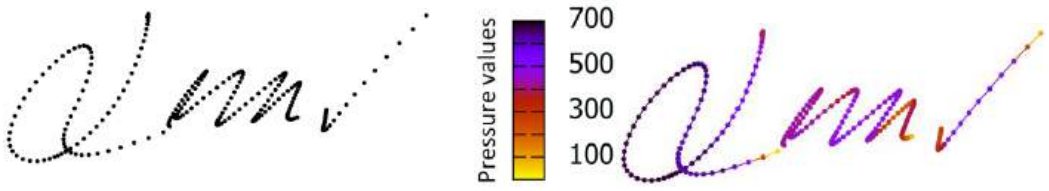
5.6.4 Even though different DCS solutions capture the same numerical data (X- and Y-coordinates, pressure and time values), they may code these data in a different way. This leads to the problem of limited compatibility and comparability of DCS data acquired from different solutions. Therefore, in order to perform examination, the DCS data may have to be normalized (i.e. made compatible), preferably according to the ISO/IEC 19794-7 standard. This can either be accomplished by capturing or analysis software, or by other (not DCS specific) software.

## 5.7 Illustrations of DCSs

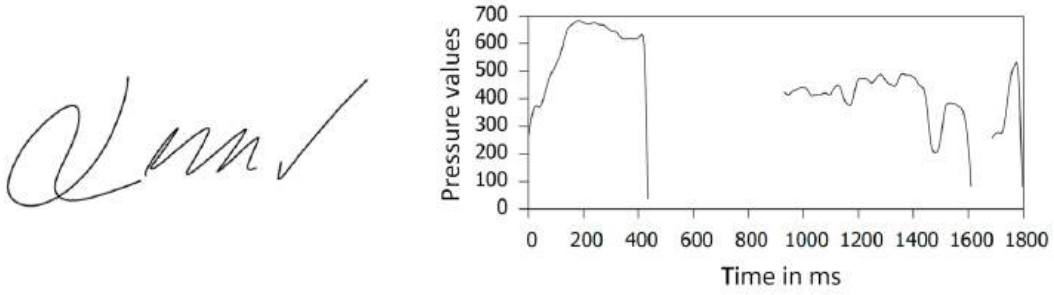
5.7.1 Numerical values can be illustrated in different ways, in order to help the expert to analyse, compare and interpret the signature features. Illustrations may also be created by analysis software described above (see section 5.4). Typical illustrations show signatures in the following ways (see also figure 1):

- point by point (X, Y coordinates)
- point by point (X, Y coordinates), with colour and/or varying point size (illustrating pressure values)
- with connected points (X, Y coordinates)
- with connected points (X, Y coordinates), with colour and/or varying point size/line thickness (illustrating pressure values)
- with lines only (X, Y coordinates)
- with lines only (X, Y coordinates), with colour and/or varying line thickness (illustrating pressure values)
- in playback animations (showing X, Y coordinates in time)
- as time dependent graphs (pressure values and passed time)

5.7.2 The list in paragraph 5.7.1 is not exhaustive as other combinations of both direct and calculated data can also be illustrated.




(a) (b)




(c) (d)

Fig. 1. (a) Point by point illustration, (b) connected points with colour, (c) lines only, (d) time dependent graph.

## 5.8 Terminology

- *Active area*
  Area of a digitizing device which allows capture of a DCS. In some DCS capturing solutions the active area may be smaller than the display.

- *Active stylus*
  Pen with electronic circuit that enables writing on signature pads, smartphones, tablets, notebooks and other devices.

- *Authentication*
  Verification of the signatory's identity.

- *Air movement (air stroke)*
  Writing movement executed above the surface of the active area or with non-detectable pressure. Only technologies with active stylus can record these movements (e.g. inductive systems).

- *Capturing software*
  Software that enables capturing of a signature digitally, in order to sign an electronic document or to provide a sample for examination.

- *Conventional handwriting and signatures (offline handwriting and signatures)*
  Handwriting and signatures produced with a writing instrument that leaves a trace on a substrate (e.g. with a pen on a paper). The procedure for forensic examination of this kind of writing products is presented in Appendix 3.

- *Crowding conditions*
  Spatial properties of a writing area (e.g. layout of a signing area).

- *DCS/DCH*
  Digitally captured handwritten signature/handwritten entry. Signature/handwritten entry, digitised by chronological sampling of the writing movement, that consists of a series of data points (synonyms: biometric signature, biodynamic signature, dynamic signature, digital handwritten signature, handwritten electronic signature, online signature).

- *DCS capturing solution*
  Specific combination of a digitizing device and software used to capture DCSs.

- *Digital ink*
  Visual feedback shown on a digitizing device during the writing process.

- *Digital signature*
  This term typically refers to cryptographically based elements. Digital signatures are often used in combination with DCSs to secure the integrity of an electronic document.

- *Digitizing device (digitizer)*
  An input device used to capture DCSs by converting writing movements into digital data (typically a signature pad, tablet, smartphone, special stylus, etc.). Common devices are based on inductive (electromagnetic resonance – EMR), resistive or capacitive sensors.

- *Dynamic characteristics*
  Pressure and time related features of a DCS.

- *Electronic document*
  Any electronic media content. In the context of DCSs it is typically a PDF file (Portable Document Format).

- *Electronic signature*
  General legal term for data in electronic form that is attached to, or logically associated with, other data in electronic form and which is used by the signatory to sign. This term includes both DCSs and digital (non-handwritten) signatures.

- *Force*
  See “Pressure”.

- *Global features/characteristics (in contrast to local characteristics)*
  Characteristics related to a DCS as a whole (e.g. total time, total distance, average pressure, etc.).

- *Hash value*
  Unique numerical value that identifies the content of a file. It is produced by a cryptographic algorithm (hash function) that reduces data from a variable length (from file content) to a fixed length.

- *Hybrid signature*
  A signature which was produced with ink on a substrate, and simultaneously digitized during the writing process. Thus, one writing movement results in two representations.

- *Inking pen (in context of DCSs)*
  Stylus, which is equipped with an inking tip but can also be used to record a DCS on certain devices simultaneously.

- *Local features/characteristics (in contrast to global characteristics)*
  Recorded/calculated characteristics of individual points of a DCS (such as position, time, pressure, velocity, acceleration, etc.).

- *Metadata of a DCS*
  Information describing the system/device(s) used, such as type/model, operating system, time, technical information of the device (e.g. scaling information of recorded data), GPS coordinates, etc.

- *Pressure*
  Pressure or force values are given by DCS capturing solutions for each data point in specific units. Even though from the physical point of view pressure is force over area, in this context, the terms “force” and “pressure” are used as synonyms.

- *Static characteristics*
  Characteristics based on graphical representation (an image) of a DCS, such as style, size, vertical and horizontal proportions, slant, alignment, shape, construction, etc.

- *Stylus*
  A pen used to produce a DCS.

- *X coordinates*
  Recordings of the horizontal position of the tip of the writing instrument on the active area.

- *Y coordinates*
  Recordings of the vertical position of the tip of the writing instrument on the active area.

# 6. PRESERVATION AND HANDLING OF ITEMS

6.1 For conventional documents see section 6 of Appendix 3.

6.2 Regarding digital evidence, as an additional precaution it may be useful to create a working copy of a file, to ensure that the analysis software cannot corrupt the original data (this may require the assistance of an IT-specialist). When receiving the data files, both within or outside of the laboratory environment, contemporaneous records shall be made. These records shall be inserted into the resultant case file and list the items that were received, the software and hardware used to record and/or decrypt the numerical signature data, the source of the data (e.g. bank etc.) and physical signing conditions.

6.3 In rare cases where the examiner might receive the original storage device, the examiner should, depending on local regulations, either request a copy or make a copy of the DCS's document file. Altering the original file still residing on the original storage device must be avoided.

6.4 Although working on a signed electronic document file that is also stored elsewhere poses no risk of destroying evidence, a backup of the transmitted data files should be made. Any alteration to the numerical DCS's data has to be recorded in the case notes.

6.5 The FHEs should be aware that, while working with numerical signature data, they are handling information that is considered biometric. Therefore it may be regulated by local/national legislation.

## 7. EQUIPMENT/INSTRUMENTATION/OPERATING CONDITIONS

7.1 For conventional handwriting and signatures see section 7 of Appendix 3.

7.2 The principle equipment for examining DCSs is a computer terminal equipped with suitable analysis software (see section 5.4). Specialised DCS analysis software is available from different providers of DCS capturing solutions. General data analysis tools (e.g. spreadsheet or statistical tool) can be used as well.

7.3 For the forensic analysis of DCS, it is recommended that the FHE has access to software with the following features:

- Access to numerical values of DCS's file (X, Y, pressure and time values).
- Playback (video) capabilities for DCSs.
- Pressure visualization.
- X, Y type graph support (for plotting different types of data).
- Time calculation (total time, contact time and time of air movements).
- Velocity calculations.
- Air movements visualization.
- Dimensional measurement capabilities.

7.4 **Decryption of questioned material**

7.4.1 In most cases, the numerical signature data is encrypted within the document file and needs to be decrypted before examination. To achieve this, the mandating authority should approach the DCS capturing solution administrator, who is in possession of the decryption keys. After decryption, signature numerical data, together with other relevant information, should be delivered to the expert in a secure way.

7.4.2 It is also possible to request the decrypted data directly, but it should be ensured that the available metadata is also obtained or is communicated by the DCS capturing solution administrator. In that case, special attention should be given to the question whether the decrypted data is unchanged and corresponds to the signature displayed in the PDF file.

7.4.3 Decryption of the DCS's data must respect local rules and regulations.

# 8. CROSS REFERENCED MATERIAL

8.1 See section 8 of Appendix 3.

# 9. PROCEDURE

9.1 The flow chart shown in section 12 of this Appendix gives a schematic representation of the steps undertaken in the course of a forensic examination and comparison of DCSs.

9.2 **Initial assessment**

In addition to the procedure described in section 9 of the BPM, the initial assessment should also include considerations as to whether the examiner will obtain access to the decrypted numerical data and to the relevant analysis software. Other factors that should be taken into account include availability of all the information about the solution used to capture a questioned DCS and physical signing conditions applied. In some cases, it might be necessary to acquire additional software compatible with a questioned DCS, to request access to such a solution or to ask for the numerical DCS's data or other information.

9.3 **Feature assessment**

The notes below detail some of the features that may be assessed in the course of the examination. Feature assessment should be addressed on a case by case basis, as not all of these features will be relevant in every case.

9.3.1 For conventional handwriting and signatures please refer to section 9.3 of Appendix 3.

9.3.2 For DCSs the following considerations should be made:

- Type of digitizer sensor technology used:
  - inductive/electromagnetic resonance (EMR)
    based on the principle of electromagnetic induction between a pad and an active stylus. Because the writing position is captured with induction, and not by force or pressure related principles, writing movements with the pen tip above the surface of a pad (air movements) can be registered. A certain force is needed to register a contact between the pen and the surface of a pad. As a result, strokes where the pen tip touches the surface of a pad very weakly, can be coded as air movements.

  - resistive
    based on resistors that register pressure applied by any writing instrument. Sensors usually have a default minimum readable force, therefore strokes produced with very weak pressure may not be recorded.

- capacitive
  based on detecting an instrument that is conductive (i.e. finger or a stylus with a conductive tip). Therefore, many styli designed for resistive or inductive technology will not work here, because they are not conductive. Pure capacitive systems do not allow to differentiate between various pressure levels. Thus, they only register whether there is a contact between the writing instrument and the sensor.

- Others

- Characteristics of visual feedback (digital ink).

- Type of writing instrument used (e.g. stylus, finger etc.).

- Type of visual information displayed on the capturing device of a questioned DCS (if applicable; figure 2). This information may influence several handwriting characteristics (see section 9.3.1).

- File format in which the numerical data of a questioned DCS was stored.


Fig. 2. (a) No visual information on the active area, (b) single line as visual information on the active area, (c) example of intense visual information projected on the signature pad for a bank transaction, (d) example of visual information projected on the entire screen and selection of a specific area of the screen as active area for a DCS.

9.3.3 Assess the amount of available material for examination:

- See section 9.3.1.6 of Appendix 3.
- Conventional samples could be used for comparison with a questioned DCS and vice versa, considering possible limitations (see section 9.4).

## 9.4 Reference material

9.4.1 To capture reference signatures during DCS case work, it is recommended to use a digitizing device with a capturing software. Such a capturing solution may be included in the aforementioned DCS analysis software or it might be standalone. To obtain the best results, the software/hardware combination should be as close as possible to the one used to capture a questioned DCS. Information on the solution used might be found in the metadata of a questioned DCS, in the PDF file or it may be communicated by the solution administrator.

9.4.2 In case work, conventional signatures may be additionally used as reference samples for the examination of a questioned DCS. If it is not possible to obtain/acquire samples of DCSs, the reference material may consist of conventional signatures only. In such a case, limitations in the comparability of certain handwriting characteristics have to be considered (see section 9.7.4). Some characteristics, such as writing velocity and force/pressure distribution, are not directly comparable. Other characteristics, such as (fine) elements in the signature/character shape or the signature size, could be influenced by the different media.

## 9.5 Characteristics of DCSs

The following general and specific characteristics should be analysed and compared in questioned and known DCSs. The results of a comparison of these features (similarities and differences) should be noted.

9.5.1 General characteristics

Most DCS analysis software offer calculations for distances and other measurements. However, the calculations or illustrations offered by the analysis software could include errors that an FHE should be aware of. It is a responsibility of the examiner to check if the data is correct. General characteristics are:

- Style and legibility
  See section 9.4.1 of Appendix 3.

- Size
  Features such as the relationship between the size of the characters and the writing lines. For DCSs, the size of the active area and the visual information projected on the display may constrain the space for the signature, which can affect recognizable features (see figure 2).
  When comparing size features between DCSs and conventional handwriting or signatures, the real dimension of the recorded DCSs needs to be taken into account and replicated for the visual part of the examination. This may be different depending on the scaling information of the DCS capturing solution.

- Proportions
  See section 9.4.1 of Appendix 3, taking into consideration that the relations between height and width might be disturbed in DCS without scaling information.

- Spacing
  See section 9.4.1 of Appendix 3, taking into consideration that the spacing might be disturbed in DCS without scaling information.

- Layout
  Placement of a signature on the active area. It can only be compared if the crowding conditions of the disputed and reference DCSs were similar.

- Slope
  See section 9.4.1 of Appendix 3.

- Pressure
  DCS's data can contain pressure values. These values can be analysed and compared in various ways, such as visualized in colour graphs or time plots and processed by different algorithms. Please note that the reliability and validity of pressure data may differ between DCS capturing solutions.

- Duration
  Data of DCSs usually contain time information which allow the calculation and comparison of the total duration of execution as well as contact duration and pen up duration. Also, the duration for selected segments may be useful for an examination. When examining time related features, it must be considered that some DCS capturing solutions also stop registering time during pen lifts, which could result in distorted time related features.
  There could be evidence of a slowly executed forgery, including a high level of jerkiness in the writing line and unusually long execution times. If present, these should be noted (see figures 3 and 4).

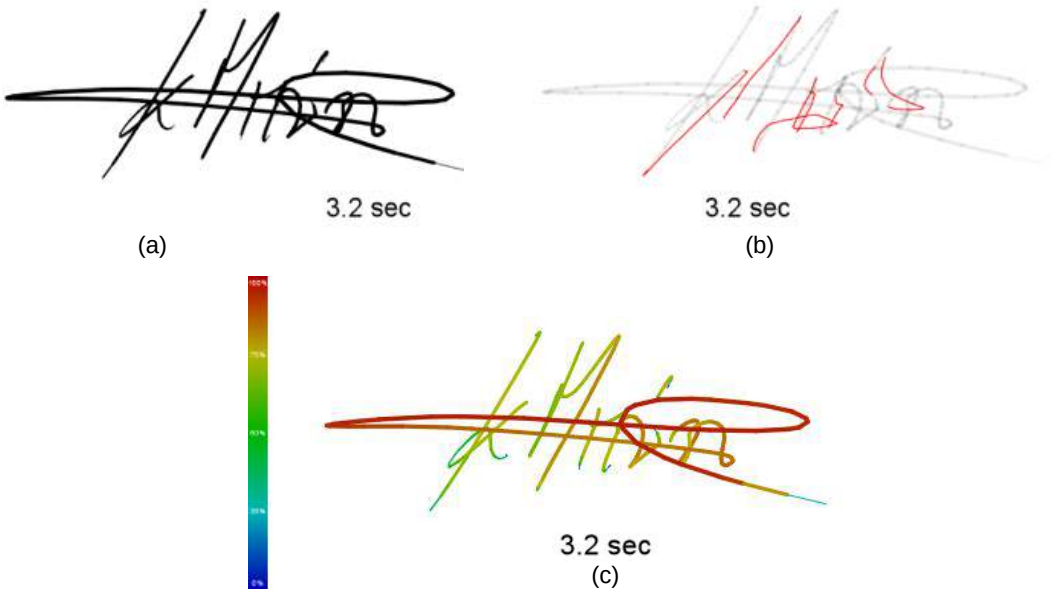



Fig. 3. (a) Linear representation, (b) air movement representation and (c) pressure representation of a genuine signature.

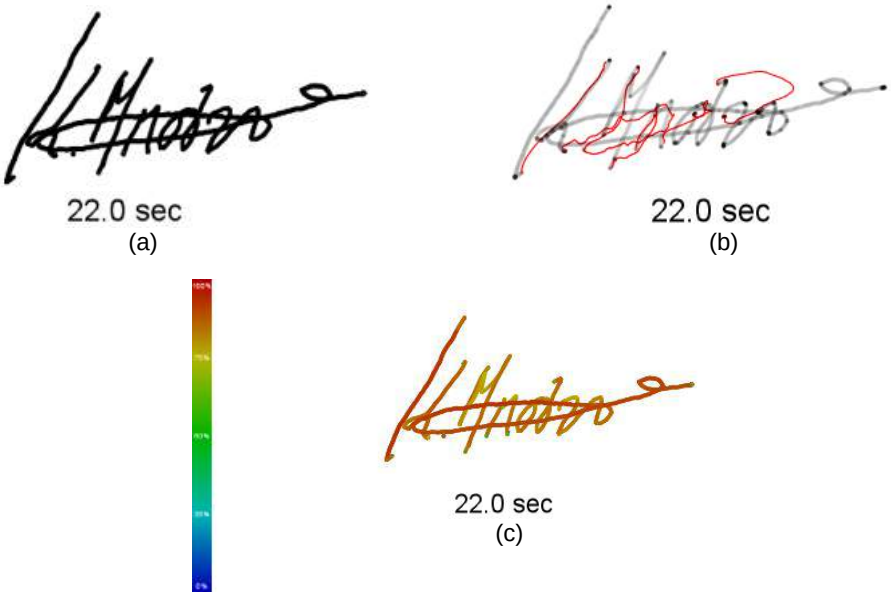



Fig. 4. (a) Linear representation, (b) air movement representation and (c) pressure representation of a traced forgery. Note the difference in the time of execution of this traced signature (22.0 s), when compared to the genuine signature in Figure 3 (3.2 s).

- Velocity
  Velocity and its derivations (such as acceleration and jerk) are not recorded directly during the execution of a DCS, but can be calculated based on the data points (X, Y coordinates and time values). These characteristics can be analysed and compared in various ways (e.g. regarding the mean value of a signature, illustrations using a colour scale or time plots) and processed by different algorithms.

- Pen lifts
  As in the examination of conventional signatures, the number of pen lifts, their location within a signature, as well as the connecting paths of characters, should be part of the analysis and comparison.

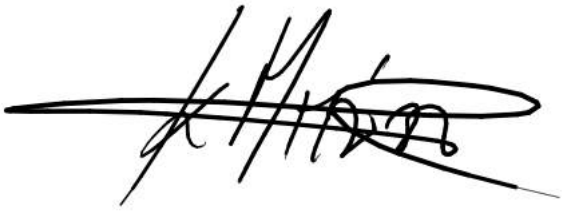
- Sequence of strokes
  The sequence of individual stroke execution can be determined/observed in DCSs. This may be of high significance and should be analysed and compared.

- Air movements trajectory (air strokes)
  Trajectory of the pen in between contact (strokes) may be significant and may exhibit a unique pattern (see figure 5). This should be observed and compared (if applicable). The following considerations must be taken into account when examining air movements:

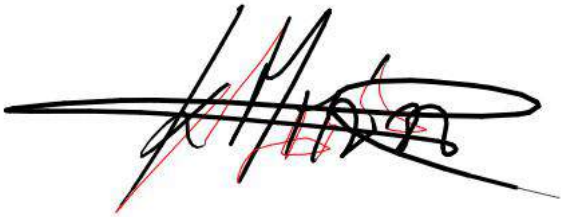
  - Some DCS capturing solutions do not record air movements, so these features may not be available.

  - DCS capturing solutions that record air movements have a cut off height above which no movement is recorded. Some software will connect the cut-off point and the return point with a single straight line. This should

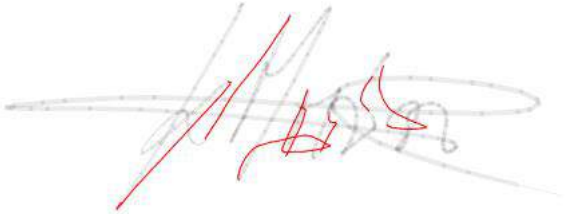
be taken into account and the examiner should know that this artefact does not represent the real path that the pen/hand followed during execution.



(a)



(b)



(c)

Fig. 5. (a) Representation of signature, (b) representation of signature including air movements (red lines), (c) representation of air movements only (red lines) and representation of the signature (grey lines).

### 9.5.2 Specific characteristics

For individual character shape, proportions, construction, parts of the signature, character combinations and connection of letters see 9.5.1 of Appendix 3. Some DCS analysis software allows the isolation of data points and, hence, representation of specific parts of the signature can be easily isolated (figure 6).

Fig. 6. Segmented analysis of a complex signature by isolating parts of the signature through selection of points recorded.

9.5.3 Example of representations of DCS features (figures 7–10): the examples on the left are representations of a genuine DCS, while a forgery is illustrated on the right.

Fig. 7. Representations of DCSs showing the pen movements by connected lines. No air movements are shown.

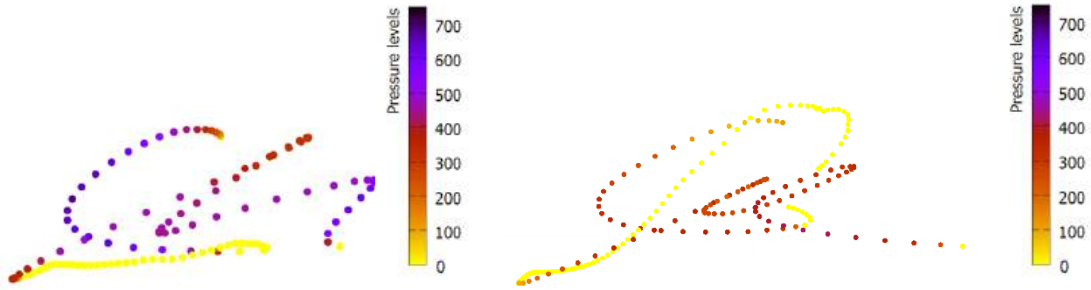



Fig. 8. Representations of DCSs showing the data points (X- and Y-coordinates) in different colours, according to the recorded pressure levels. Air movements are shown in yellow (pressure level 0).

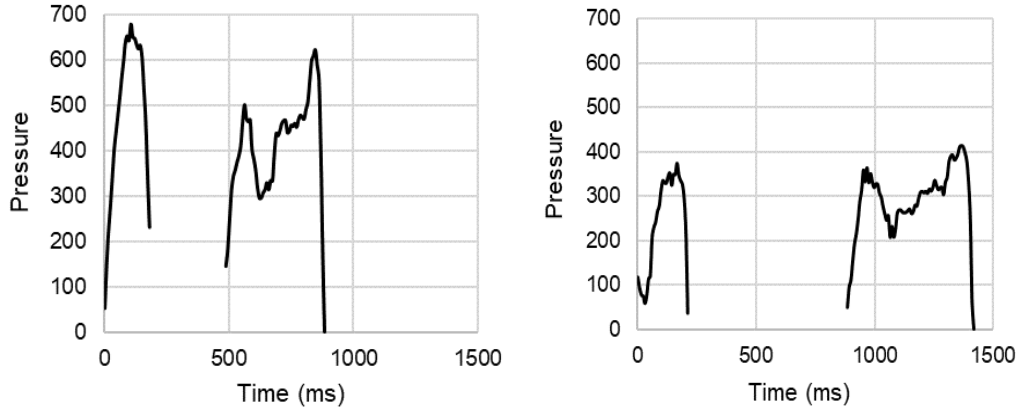



Fig. 9. Pressure time plots showing the pressure level in function of execution time.

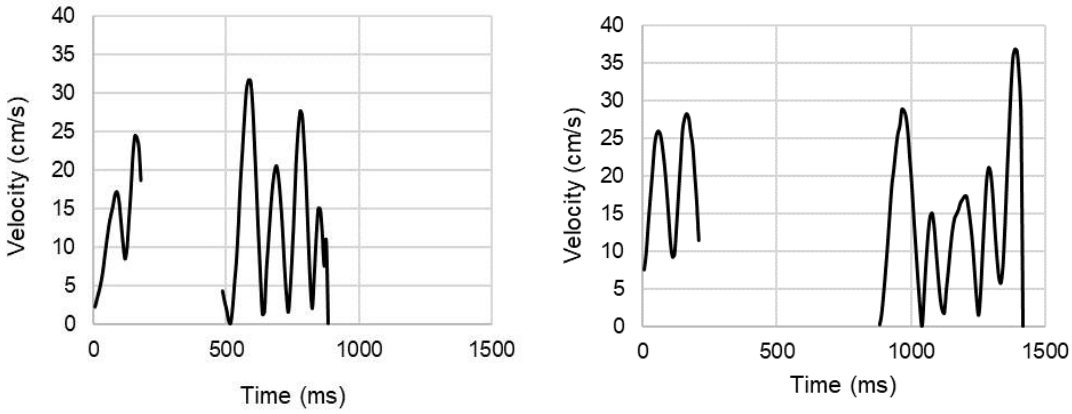



Fig. 10. Velocity time plots showing the calculated velocity in function of execution time.

## 9.6 Evaluation, interpretation and reporting

9.6.1 On completion of the examination, a FHE undertakes a detailed evaluation of the relevant findings and their significance. These findings will include:

- Quantity and quality of signatures (see section 9.3 of Appendix 3).
- The DCS capturing solution and conditions (see section 9.3.2).
- Results of the comparison of general and specific characteristics (see section 9.5).

9.6.2 The evaluation will include a determination of the strength and significance of all of the relevant similarities and differences identified during the examination.

9.6.3 Once evaluated, a conclusion is formulated using the relevant conclusion scale.

## 9.7 Limitations concerning the conclusions in DCS examination cases

9.7.1 The evaluation of a DCS examination by a FHE only reflects the genuineness of a questioned DCS, but not the integrity of the electronic document (e.g. whether or not the document's data were altered after it had been signed). Aspects regarding the integrity of an electronic document fall into the competence of forensic IT.

9.7.2 By signing in the conventional way, the signatory creates a physical connection between the signature and the paper document, which makes them inseparable. However, signing an electronic document with a DCS is a very different way of binding them together. It is based on cryptographic integration of a DCS with a specific electronic document, which, despite being designed to provide as much security as possible, does not make them inseparable.

9.7.3 This significant distinction in signing documents introduces specific limitations concerning conclusions of forensic handwriting examination of DCSs. For conventional handwriting and signatures, a FHE can conclude about a signatory being responsible for signing a document. However, regarding an electronic document, the expert can only conclude about a DCS's authenticity, since the examination of the connection between the DCS and the document fall into the competence of forensic IT. Determining the signatory of the electronic document could be a conclusion resulting from a combined forensic examination, in which the handwriting examination would account only for the genuineness of a questioned DCS (see section 5.3.2).

9.7.4 Examination of a DCS with no numerical data and with non-normalized numerical data.

9.7.4.1 Examination of a graphical representation of a DCS only (e.g. an image of a DCS on an electronic document that does not contain numerical data, sometimes referred to as "flat PDF") can be considered the equivalent of examining a conventional signature from a non-original document (e.g. a copy, see Appendix 3, paragraph 9.7).

9.7.4.2 Graphical representations may vary in quality (figure 11). Therefore, when examining a DCS only on the basis of an image, its quality should be evaluated in order to determine whether the handwriting is sufficiently detailed for comparison purposes.

(a) (b)

Fig. 11. (a) Poor quality image of a DCS, with many details lost, (b) good quality image of a DCS, with more details available.

9.7.4.3 If the quality of the DCS image is poor, then comment should be made to this observation and limited or no significance should be attributed to any comparison made.

9.7.4.4 It should be considered and commented within the notes that numerical data were not examined which caused limitations or even prevented the FHE from examining certain features.

9.7.4.5 As stated in 5.6.4, it is possible that FHE will have to compare DCS non-normalized data. Comparison of such data is feasible with consideration of the inherent limitations of such an approach. The FHE should proceed with caution, taking into account the different properties of the DCS capturing solutions used.

## 10. QUALITY ASSURANCE AND COMPETENCY

10.1 The competencies relevant to the Examination and Comparison of Handwriting are summarized in Appendix 1 “Key Knowledge Requirements for Forensic Handwriting Examination”.

10.2 The competencies relevant to the Forensic Examination and Comparison of DCSs include the following knowledge and abilities:

- handling of electronic evidence,
- definition of a DCS,
- limitations with regard to forensic examination of DCSs,
- use of software designed to capture, extract and analyse DCSs,
- handling numerical data of DCSs,
- plotting of DCSs illustrations and graphs,
- terminology as listed in paragraph 5.8,
- use of instrumentation listed in section 7,
- assessment of characteristics listed in section 9.5,
- evaluation of dynamic characteristics.

10.3 The specific quality procedures for each department should be detailed within their Management System.

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11.1 There are increasingly more publications on the subject of DCSs. It is impossible to compile a complete list of all of these. The principle books and articles on DCSs are detailed bellow.

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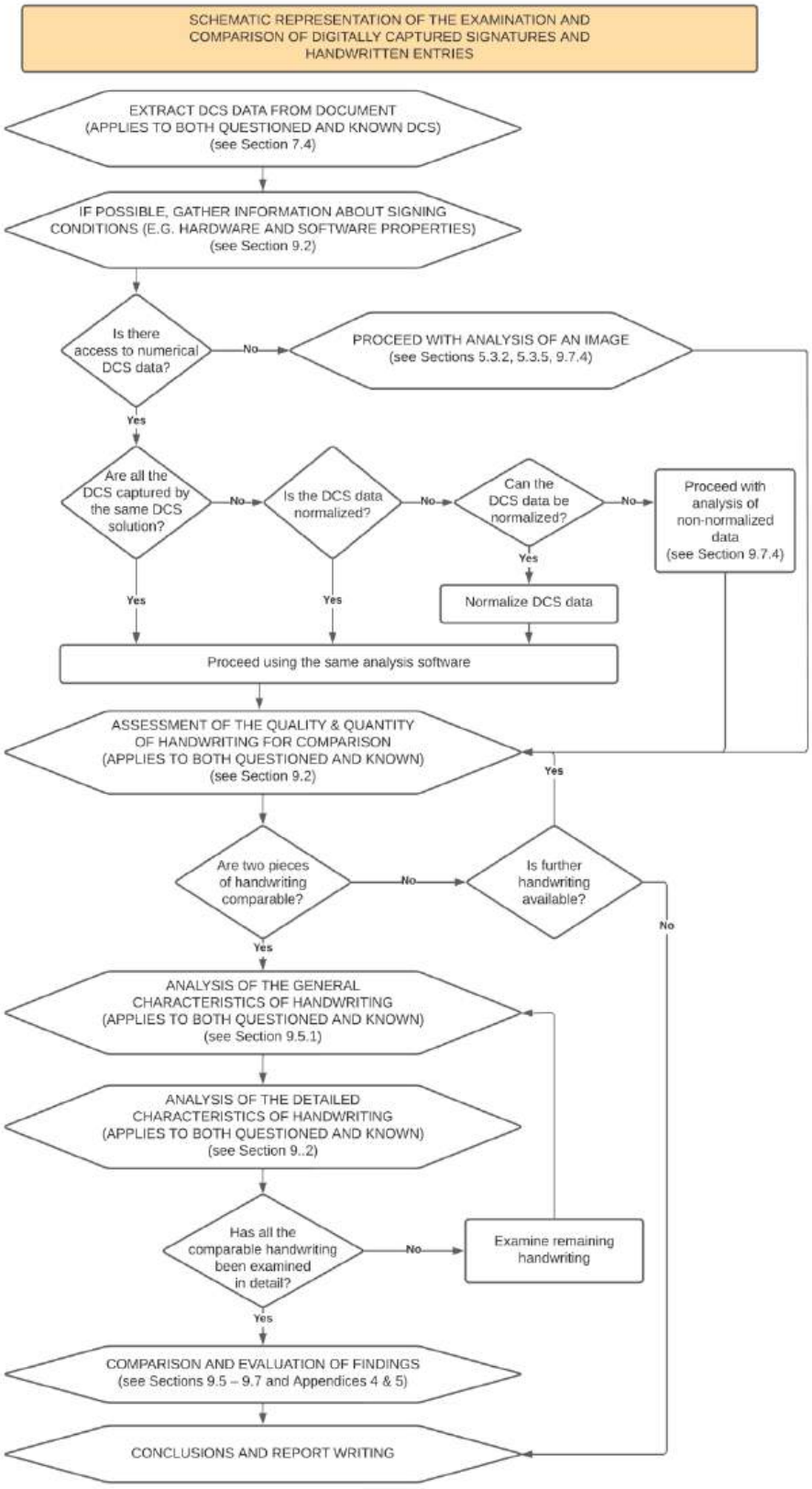
Zimmer, J., Kalantzis, N., Dziedzic, T., Heckeroth, J., Kupferschmid, E., Fernandes, C., Geistová Čakovská, B., Branco, M., Axelsson Spjuth, K., Vaccarone, P., & Kerkhoff, A.: The challenge of comparing digitally captured signatures registered with different software and hardware, *Forensic Science International, Volume 327, 2021, 110945, ISSN 0379-0738*, available at: doi.org/10.1016/j.forsciint.2021.110945

# 12. OVERVIEW OF THE EXAMINATION PROCESS



# APPENDIX 7 – SAMPLING

## 1. INTRODUCTION

1.1 The aim of this appendix is to provide a framework for the processes of collecting handwriting samples for casework in the field of forensic handwriting examination. This includes both conventional (pen-and-paper) and digitally captured signatures and handwritten entries. It aims at guiding to obtain quality samples, well-suited to questioned writings of a specific case, both within and outside of the laboratory environment.

1.2 While the Appendix itself is mainly directed at laboratory-based staff, including forensic handwriting experts (FHE), it also introduces a document directed at lay people who may act as samplers (see section 9).

## 2. SCOPE

2.1 This document encompasses the whole procedure of sample collection, both for request and course of business specimens. It covers the preparation stage, at which a sampler becomes familiar with the case, develops a specific approach to sampling and identifies and assists in preparing relevant resources.

2.2 It also provides recommendations regarding the conduct of a sampling session, at which writings are produced by a subject in front of the sampler, who dictates what should be written and may give further instructions.

2.3 Specific guidelines for the process of DCS sampling, as well as for collection of course of business samples are formulated in the sections 6 and 7. The need for proper documentation of all activities is emphasised and advice is provided on how to do this (see sections 5.3 and 6.4).

## 3. DEFINITIONS AND TERMS

3.1 For Definitions and Terms related to forensic handwriting examination in general see Appendix 8. For Definitions and Terms related to DCS in general see Appendix 6.

3.2 Additionally, the following terminology is used in this Appendix:

- **Sampler** – an individual who carries out the sampling process, such as a FHE, a technician, or other laboratory staff member. It can also be a representative of a third-party authority, such as a police officer, a judiciary, etc. There can be more than one sampler present at the sampling session.
- **Subject** – an individual who is requested to produce handwritten samples at the sampling session or whose course of business writing are to be collected.
- **Sampling instruction for lay people** – list of recommendations on how to collect request samples, prepared by a FHE for a non-FHE laboratory staff

member. Sampling instructions for lay people can be case-specific or general (see section 9).

- **Sampling session** – a legal action/proceeding at which a subject is to produce requested handwritten specimens under the supervision of a sampler.

# 4. INITIAL CONSIDERATIONS

4.1 The quantity of reference samples to be collected for casework is at the decision of the Reporting Scientists, and is dependent on the nature of the questioned material. In particular the specimens should reflect natural variability of the writer's handwriting, and correspond to the questioned writings in terms of writing style and contemporaneousness.

4.2 Subsequently the decision whether or not further samples need to be obtained and submitted in a particular case (request and/or course of business) belongs to the Reporting Scientist, who must take into consideration local regulations. The decision is taken upon initial examination of the writings in question and available reference samples (if any).

# 5. SAMPLE COLLECTION PROCEDURE

## 5.1 Preparation stage

5.1.1 The sampler should become familiar with the questioned writings in terms of the writing implement and substrate used to produce them, as well as their style and line quality. This is essential in defining what kind of reference samples are required. It may also be beneficial for the sampler to become familiar with the supposed circumstances in which the questioned writings were produced.

5.1.2 If possible, the sampler should become familiar with known samples from the subject by conducting a preliminary assessment. This may be helpful in recognising disguise attempts at the sampling session and avoidance of certain styles of writing or certain types of signatures.

5.1.3 It is recommended that the sampler determines whether or not the subject speaks the respective local official language and considers whether or not the assistance of an interpreter will be required.

5.1.4 Before the sampling session starts, the sampler should prepare relevant resources required for the process, which will include the following:

- **writing implement(s)** – it is recommended to use writing implement of the same type as the one the questioned writings were produced with, at least for part of the samples;
- **writing substrate** – it is recommended to use standardized forms for sample collection (i.e. forms with pre-printed information; see section 8). These forms may be customised by adding case-specific content (e.g., pre-printed lines or boxes) to mimic the layout of the questioned document(s);

- **writing surface** – if this is not justified by the circumstances of the case, the substrate on which samples are produced should not be placed directly on hard or rough surface (e.g., on a desk) during sampling session. Therefore, a smooth underlay such as a desk pad or a pile of paper should be provided to allow for best possible representation of writing pressure;
- **dictated text** – a text that will be dictated to the subject. It is recommended to use a standard text that includes all the letters that appear in a relevant alphabet, both in uppercase and in lowercase, as well as all the numerals. Alternatively, random text can be used, e.g. part of an article from a newspaper or a passage from a book;
- **case-specific entries** – names, words, expressions, texts, numbers etc. that contain wording identical or similar to the questioned writings.

## 5.2 Sampling sessions

5.2.1 Immediately before the start of the session the identity of the subject must be verified.

5.2.2 The questioned handwriting must not be shown to the subject, neither in original nor in a copy.

5.2.3 The subject should be discouraged to make corrections or cross-outs in the samples produced. In case of a mistake, they should leave original entry untouched and repeat it correctly. The sampler should note any circumstances where this occurs.

5.2.4 All the samples should be dictated to the subject at such a pace that they can keep up with notation.

5.2.5 The samples should be as close to the questioned writings as possible in terms of their type, style and complexity. However, in some cases it may be necessary to also collect samples in different styles, to better recognise the range of writing habits of the subject.

5.2.6 It is recommended that the samples produced on request, or part of them, mirror the questioned writings in terms of their wording. However, it is recommended to collect samples with different content such as a standard or a random text, alphabet (in lower-case and/or upper-case letters), numbers, all types of signatures, etc.

5.2.7 The subject can be instructed to write in a certain style(s), such as block capitals, disconnected lower-case cursive lower case.

5.2.8 The subject may be instructed to write with an unaccustomed hand or a hand that is claimed to be unaccustomed.

5.2.9 The subject can be instructed to adopt a different position from the standard one while producing samples e.g. standing with a sampling form placed on a desk, standing with a form placed against a wall or sitting with a form placed on one’s knees.

5.2.10 Any instructions given to a subject, such as the adoption of a non-standard writing position or a particular style, should be noted on the specific sample sheet (see paragraph 5.3.3).

5.2.11 If any abnormal behaviour of the subject is observed, that may result from a disguise attempt, it should also be noted on a relevant sample sheet and/or in the protocol.

5.3 **Documentation**

5.3.1 Sample sheets may contain the following information:

- case number/identifier
- date of collection
- full name and signature of the subject
- full name(s) and signature(s) of all the samplers present at the sampling session
- space for annotations (optionally).

5.3.2 Relevant sample form should be prepared, that may contain the following information:

- date and place of the sampling session
- details of the subject (including ID number)
- mandating authority of the case
- case numbers
- number of sample forms
- signature of the sampler
- signature of the subject.

5.3.3 Sample sheets and/or forms should also contain space for annotations to allow the sampler for adding comments e.g., about a non-standard writing position, writing with an unaccustomed hand, any instructions given to the subjects while writing, abnormal writing behaviour, etc.

5.3.4 A template sampling sheet and a template sampling form are presented at the end of this Appendix. These designs can be freely used and adapted to the needs of individual laboratories.

## 6. DCS/DCH SAMPLE COLLECTION PROCEDURE

6.1 The sample collection procedure described in section 5 in general apply to the sampling of digitally captured signatures and handwritten entries (DCS/DCH) as well. DCS/DCH-specific steps and considerations are presented below (for reasons of clarity, only the acronym “DCS” will be used).

6.2 **Preparation Stage**

6.2.1 The sampler should prepare a relevant hardware and software combination(s) to use for sample collection. In order to facilitate subsequent data analysis, it is recommended that the same hardware and software, with the same settings,

is used to collect samples, as the one the questioned writings were captured with. If this is not possible, the use of digitizer based on the same sensor technology is recommended. Other hardware or/and software can be used as well, if they allow capturing numerical DCS data of acceptable quality.

6.2.2 Circumstances of the collection protocol of the questioned DCS are to be replicated if possible. The following aspects could be relevant when encountered during signature execution:

- position of a digitizer (angle, height, firm/yielding underlay),
- writing position of a subject (standing/sitting/unusual),
- crowding conditions (information displayed on the surface of a pad),
- size of active area,
- visual feedback (if the samples are to be produced directly on the surface of a pad),
- physical properties of writing implement and active area interaction (type of stylus, type of tip, tether, type of surface of active area).

6.2.3 If the specimens are to be compared to the questioned conventional writings, collection of hybrid samples can be purposeful. Hybrid samples are produced with ink on a substrate, and simultaneously digitized during the writing process (thus, one writing movement results in two representations). This will allow to capture numerical DCS data whilst granting the subject a “pen and paper experience”. If adhesive notes are used, they should be of similar size to the signature pad’s display.

6.3 **Sampling session**

6.3.1 The sampler initiates the software for the DCS collection and checks if the software and hardware are functional.

6.3.2 Depending on the intended use of the collected sample, the sampler decides whether the digitizer should display any information.

6.3.3 Depending on the case circumstances, the subject may be instructed to press a certain button/not to press any button after producing a sample, which may affect the final air movement trajectory.

6.3.4 The subject should be given the appropriate stylus and instructions on where and when to sign on the active area of the selected digitizer. Depending on the case circumstances it may be purposeful to instruct a subject to write with a finger.

6.3.5 If a subject is not familiar with signing/writing on a digitizer, the number of collected samples may be increased accordingly.

6.3.6 For the collection of hybrid samples, a paper substrate is positioned on top of the digitizer and the sample is executed with a compatible inking pen. The substrate should be fixed to the digitizer to avoid displacement during sample collection. After each sample is produced, the sampler should remove the used substrate before placing a new one.

### 6.4 Documentation and Legal Considerations

6.4.1 Upon completion of the collection phase, the sampler should save the collected samples and name the corresponding file(s) accordingly. If required by the law or quality management rules, the files may be encrypted.

6.4.2 Substrates used for hybrid signatures should be marked and stored safely (e.g., by stapling them to a blank sampling sheet).

6.4.3 Because numerical DCS data are considered biometric data, they can be subject to local regulations. These regulations may be different from those related to conventional samples. The legal aspects of the collection, use and storage of said biometric data should be considered by the sampler. It may be required to obtain a written consent from a subject for these actions or to inform them about the conditions of access, storage and treatment of the collected samples.

## 7. COURSE OF BUSINESS SAMPLES

### 7.1 Preparation stage

7.1.1 If the decision to request course of business samples is taken, potential sources are selected. This may include (not exclusively) the following documentations: case files, administrative documents such as ID/passport/driving license applications, personnel files from the workplace, tax files, private writings from any party involved, etc.

7.1.2 The selection should be based on the case circumstances. For example, if deteriorated writings on a last will are questioned it may be beneficial to collect health records of the alleged testator which were dated around the same time as the date on the questioned document.

### 7.2 Obtaining samples

7.2.1 Depending on local regulations the samples may be obtained directly or requested via the mandating authority.

7.2.2 Depending on the suitability of the acquired samples, more specimens may be requested from the same or different sources.

### 7.3 Considerations

7.3.1 All the obtained samples must be verified with regard to their origin. It is not uncommon for official documents to be completed and even signed by persons other than the individual to whom they have been issued.

7.3.2 Particular caution should be exercised in the case of specimens obtained from the parties involved, as they may include samples produced by a different person than the actual subject (e.g. simulated signatures).

# 8. SAMPLING SHEET AND FORM

## 8.1 Template sampling sheet

8.1.1 The following sheets for sampling (see subsequent pages) is illustrative and may not include all of the relevant information. The sheets should be edited/adapted to meet the requirements of the Laboratory's management system.

| LABORATORY LOGO | LABORATORY NAME AND CONTACT DETAILS | Laboratory Form Identification No.<br>Lab. Case Reference No. |
|---|---|---|
| This area is intended for the samples that will be produced.<br>It can remain blank or be customised with printed lines, boxes, etc. | | |
| ..... *Subject's full name* | | ..... *Subject's signature, date* |
| ..... *Full Name of Sampler 1* | | ..... *Signature of Sampler 1, date* |
| ..... *Full Name of Sampler 2* | | ..... *Signature of Sampler 2, date* |
| Comments from Sampler(s) | ..... ..... | Page No. |

## 8.2 Template sampling form/minutes

| LABORATORY LOGO | LABORATORY NAME AND CONTACT DETAILS | Laboratory Form Identification No. |
|---|---|---|
| | | Lab. Case Reference No. |

**Sampling minutes**

Mandating Authority: .....

Mandating Authority Case Reference No: .....

Subject's name: .....

Subject's ID number: .....

Subject's personal details: .....

.....

Number of sample pages: .....

Sampling session details: .....

.....

.....

Sampler's comments: .....

.....

I hereby declare that I have no formal objections to the sample collection session and that the questioned writings have not been presented to me.

.....

*Subject's signature*

Name of Sampler 1: .....

Name of Sampler 2: .....

| | |
|---|---|
| | ..... *Signature of Sampler 1* |
| ..... *Place and Date* | ..... *Signature of Sampler 2* |

# 9. INSTRUCTIONS FOR LAY PERSONS

9.1 The following set of instructions can be used to assist lay persons in collecting handwriting samples.

**Model sampling instruction for lay people**

Forensic handwriting examination is a well-established method of determining the authorship of written texts, entries and signatures based on comparing individual characteristics of questioned material (Qn) with known examples of a person writing (Kn). It is therefore essential for experts to be provided with known material of sufficient quality and quantity to obtain the best possible results. To ensure this condition, it is recommended that the following directions are followed when collecting request (Kn) samples.

*Preparatory Stage*

1. The individual undertaking the sampling process should become familiar with questioned samples before the sampling session.
2. Relevant resources should be prepared, so that at least part of the samples is consistent with questioned samples regarding (Fig. 1):

- content (wording);
- style, which typically falls into one of the following categories:
  - capitals or uppercase (e.g. HANDWRITING),
  - cursive or connected lower-case (e.g. *handwriting*),
  - disconnected lower-case (e.g. handwriting).

  [Note: if the questioned samples consist of illegible/stylized signatures, such samples should be collected based on relevant name];
- type of writing implement (e.g. ballpoint pen, fountain pen, fibre tip pen, gel pen, pencil);
- layout, including sheet size, pre-printed lines or boxes, the amount of space on the document left for questioned samples, etc.

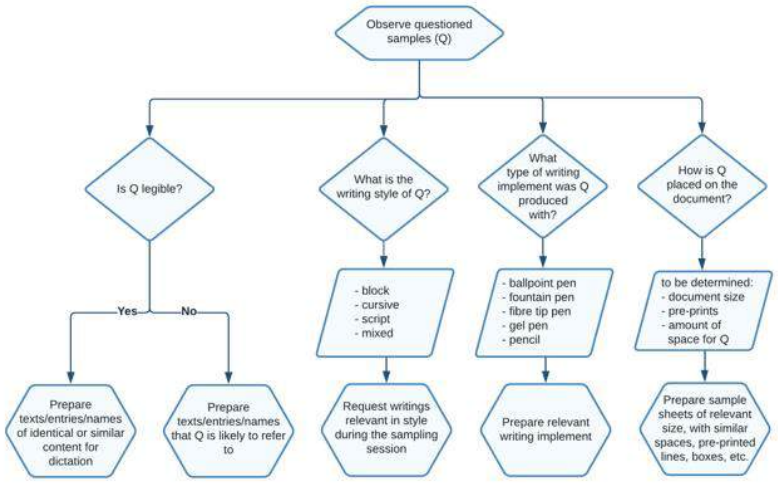



*Fig. 1. Preparatory stage of sampling*

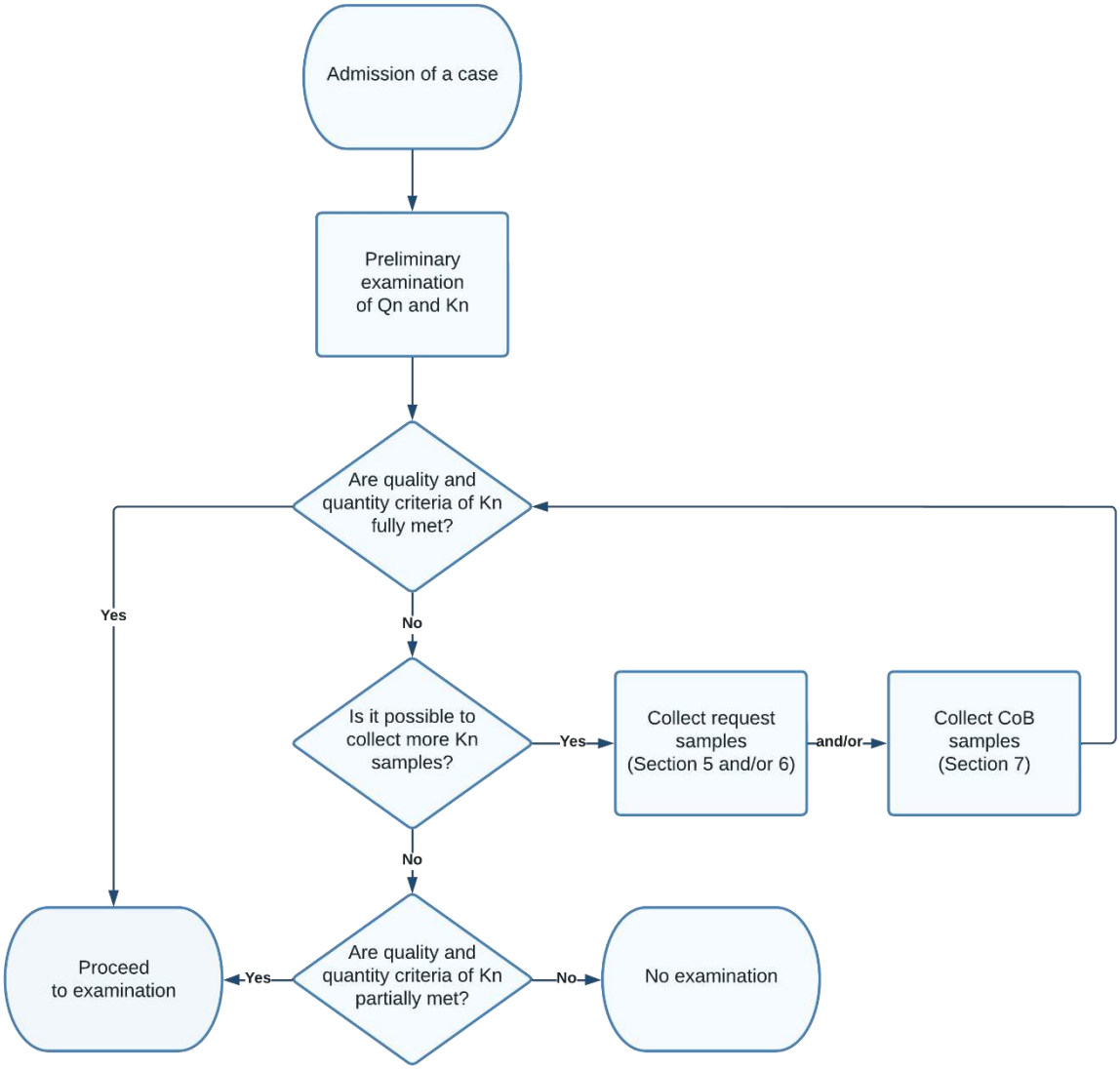
*Sampling Session*

1. Identity of the subject (the individual who is requested to produce handwritten samples) must be verified.
2. The natural, standard sitting position of the subject should be ensured.
3. The subject must not be presented with the questioned samples, in any form (i.e. neither in original nor as a copy) before or during the sampling session,.
4. All the samples should be dictated to the subject at such a pace that they can keep up with the handwriting process in a natural, undistorted way.
5. When a sheet of samples is completed, it should be removed from the subject's sight before moving on to the next sample.
6. The samples should consist of a standard text (including all the letters in the relevant alphabet and all the numerals; e.g. *The London Letter*) as well as case-specific samples (names, words, expressions, texts, numbers etc. which contain wording identical or similar to questioned samples).
7. The quantity of samples should enable the expert to study the scope of natural variation in the subject's handwriting. Thus, it is recommended that the number of handwriting samples or sample signatures follows the local regulations and requirements.
8. It is recommended to also collect some samples produced with the unaccustomed/less accustomed hand.

*Documentation and submission*

9. Appropriate documentation of the sampling session is necessary. All sampling sheets should be signed and dated by the subject. A protocol should be prepared, including all relevant case information, and signed by both the examiner and the subject.
10. All collected sample sheets and the protocol should be securely packed and submitted to the expert appointed by the mandating authority.

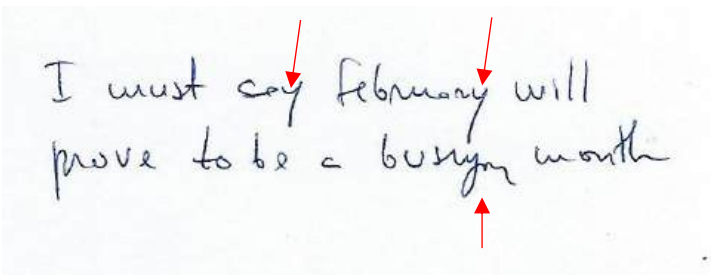
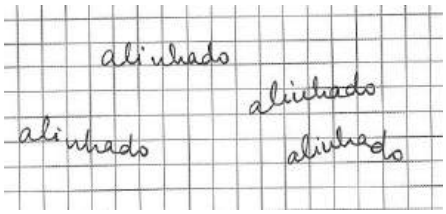
# 10. FLOW CHART OF THE HANDWRITING SAMPLING PROCESS

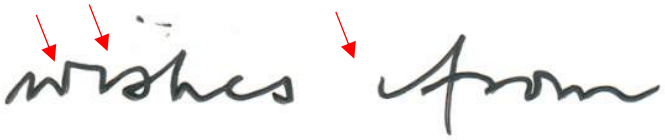


# APPENDIX 8 - TERMINOLOGY AND ABBREVIATIONS USED IN FORENSIC HANDWRITING EXAMINATION

## SCOPE

The following list, although not exhaustive, includes many of the basic terms used in the forensic examination of handwriting and signatures. The bulk of these terms have come from the Modular Forensic Handwriting Method– Version 2016 (MFHM). The list at the end includes some of the abbreviations used in the BPM.

| Term | Illustration |
|---|---|
| **Accidental** (MFHM)<br>An unusual feature or characteristic, deemed to be unintentional, not seen in the bulk of the handwritten material. |  |
| **Allograph** (MFHM)<br>A particular design of a character, where there can be more than one design per character e.g. capital letter **A** is a different allograph than a cursive letter ***a***. |  |
| **Artefacts** (MFHM)<br>Remnants. For example, trash marks are artefacts of a copying process; writing is an artefact of human movement. | |
| **Authentic** (MFHM)<br>When a document/ handwriting is genuine. | |
| **Authorship**<br>The process of writing a document. | |
| **Baseline** (MFHM)<br>The real or assumed line upon which handwriting is produced. |  |
| **Chance match** (MFHM)<br>The occurrence of naturally produced handwriting by two different writers that displays the same handwriting characteristics such that the writing cannot be distinguished. | |

| | |
|---|---|
| **Character** (MFHM)<br>Letters, numbers and symbols; graphemes. | |
| **Collected Specimen** (adapted from MFHM)<br>Samples of a known person's handwriting/signatures that have been produced throughout the course of day-to-day business. These will be either collected by the examiner or submitted by relevant parties for the purposes of comparison against questioned material. Examples include letters, diaries, business records, forms or cheques. These can also be known as normal course specimen or course of business specimens. | |
| **Common Authorship** (MFHM)<br>A comparison of handwriting where the examiner is asked to give an opinion on whether a group of questioned documents have been produced by the same writer. | |
| **Comparable** (MFHM)<br>Material that is suitable for comparison e.g. similar style, case. | |
| **Complexity** (MFHM)<br>A combination of speed, style and construction; how difficult the writing is to simulate. |  <br>Complex signature |
| **Concatenations** (MFHM)<br>Connections. |  |
| **Connections** (MFHM)<br>The union of two characters e.g. in cursive writing. | |
| **Consistent** (MFHM)<br>Similar, regular throughout a passage of writing or between multiple signatures. | |

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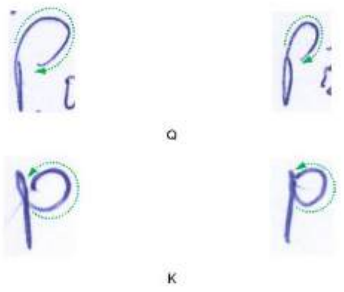
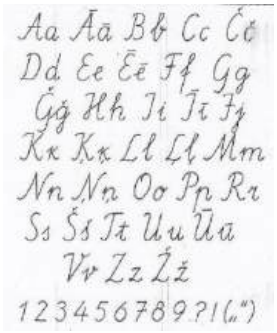
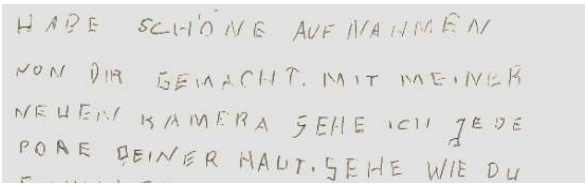
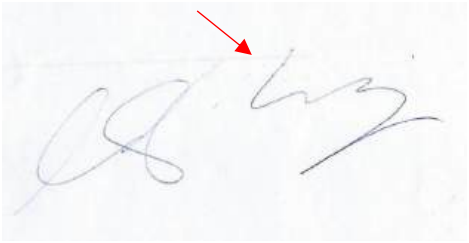
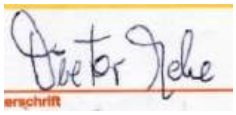
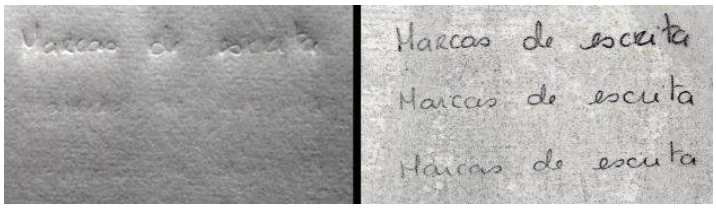
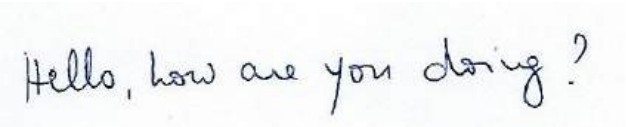
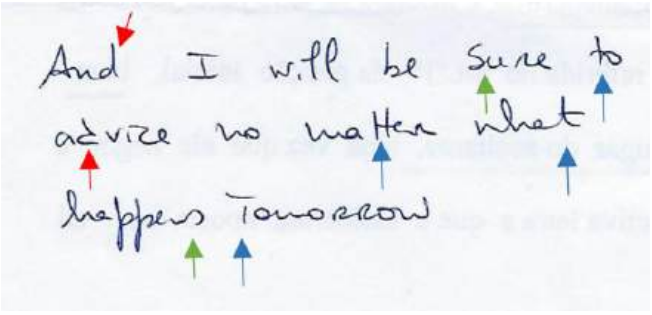
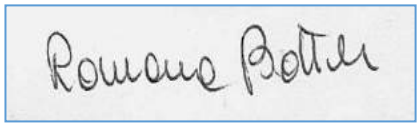
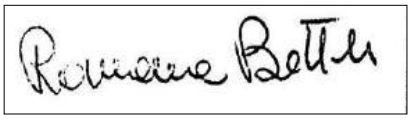
|---|---|
| **Construction** (MFHM)<br>How a character, word or signature has been produced, including features of number, direction and sequence of strokes. |  |
| **Copybook style** (adapted from MFHM)<br>A writing book of letters printed for imitation and used in schools as a teaching pad / a book, used by children in school, containing examples of writing which school students have to copy. |  |
| **Disguise** (MFHM)<br>A deliberate attempt to hide normal writing habits. |  |
| **Dissimilarities** (MFHM)<br>Differences between writings. | |
| **Drag (pen drag)** (MFHM)<br>A very fine ink stroke where the writer has not completely lifted the pen from the surface of the page between strokes. |  |
| **Embellishments** (MFHM)<br>Flourishes added to the writing. | |
| **Excluded** (MFHM)<br>Material that is not examined. | |
| **Feature** (MFHM)<br>An aspect of a character or the handwriting in general. | |
| **Flourish** (MFHM)<br>An ornamental or exaggerated pen stroke. |  |
| **Fluency** (MFHM)<br>The speed and skill level of the writing. | Fluent  |

| | |
|---|---|
| | Non-fluent  |
| **Forgery** (MFHM)<br>Non-genuine writing. | |
| **Formation Variation** (MFHM)<br>Differences in the method of constructions of a character. | |
| **Fundamental Difference** (MFHM)<br>A repeated difference in the questioned material that is significantly different to the specimen material. | |
| **Grapheme**<br>A single unit or character in a writing system (a, b, c, A, B, C, 1, 2, 3 etc) | |
| **Guidelines** (MFHM)<br>Lines that show a route to follow when simulating handwriting or signatures. These can exist in the form of pencil lines or indentations or be created by the use of transmitted light shone through a document containing the entries to be copied. |  |
| **Height Relationship** (MFHM)<br>The size differences within and between handwritten characters. | |
| **Indented Impressions** (MFHM)<br>Markings or imprints on the paper surface caused by the pressure of a writing instrument on the pages or paper above. |  <br>Oblique lighting Electrostatic detection |
| **Inter-comparison** (MFHM)<br>Comparison of handwriting on more than one document or by more than one writer. | |
| **Known handwriting (Kn)**<br>Proven samples of handwritten material from a nominated person, used to compare against the questioned handwriting. | |

| | |
|---|---|
| **Legible** (MFHM)<br>Decipherable or readable material. |  |
| **Limitation** (MFHM)<br>A constraint to the examination, comparison or opinion formation process e.g. non-original documents, limited quantity of material. | |
| **Line Quality** (MFHM)<br>A measure of fluency of handwriting, the degree of regularity; a product of a combination of features including speed, skill, fluency and pen pressure of the writing stroke. | |
| **Motor Memory (muscular)** (MFHM)<br>The memory for motor skills that controls movements such as that of the hand during the writing process. | |
| **Movement** (MFHM)<br>The motion of the writing stroke. | |
| **Natural Variations** (MFHM)<br>Normal or usual deviations that occur in repeated specimens of a person's handwriting. |  |

| | |
|---|---|
| **Non-Original (MFHM)**<br>Reproduction of a document e.g. photocopied, faxed, scanned, photographed. | Original<br>  <br>Non-original<br>  |
| **Normal Behaviour** (MFHM)<br>Any specimen or writing executed without an attempt to control or alter its usual quality of execution. Also referred to as natural behaviour. | |
| **Overwritten**(MFHM)<br>Writing over other writing. |  |
| **Pause** (MFHM)<br>A temporary interruption to a stroke without removing the writing instrument from the writing surface. | |
| **Pen Direction** (MFHM)<br>The direction the pen moves to produce a character, connection or signature. | |
| **Pen Lift** (MFHM)<br>An interruption in a stroke caused by removing the writing instrument from the writing surface. |  |
| **Pictorially consistent/similar** (MFHM)<br>Having a similar shape, allowing a more detailed examination to take place (in relation to signatures). | |
| **Pictorially inconsistent/ dissimilar** (MFHM)<br>Having a dissimilar shape, meaning no further comparison can take place (in relation to signatures). | |

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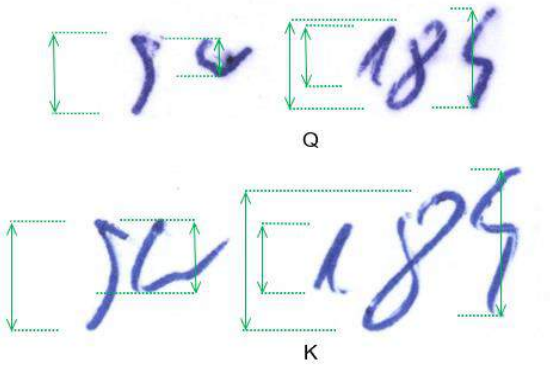
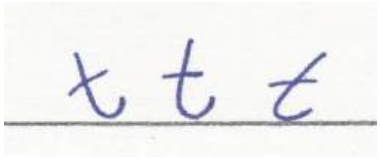
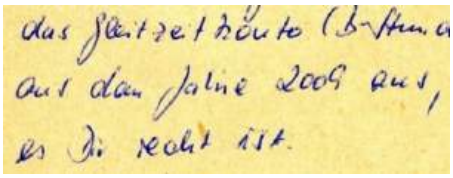
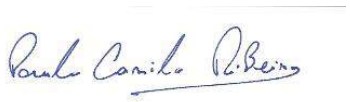
|---|---|
| **Preliminary Examination** (MFHM)<br>An initial examination preceding the main examination; giving initial observations regarding the ability to examine the items in question. | |
| **Proportion** (MFHM)<br>The height and spatial aspects within or between characters. | |
| **Questioned handwriting (Qn)** (MFHM)<br>Handwriting or signatures about which the authenticity or authorship is in doubt. | |
| **Repeated Difference** (MFHM)<br>Differences between writings that are seen consistently throughout the passages of writing. | |
| **Requested Specimen** (MFHM)<br>Specimen samples written specifically for the purpose of comparison to questioned material (as requested by an investigator). | |
| **Retouching** (MFHM)<br>To add lines or strokes in order to correct, improve or alter. |  |
| **Signature**<br>A handwritten (and often stylized) depiction of someone's name, nickname, or even a simple "X" or other mark that a person writes on documents as a proof of identity and intent. |  <br>Barack Obama |

| | |
|---|---|
| **Similarities** (MFHM)<br>Having mutual resemblance and a number of features in common. | |
| **Simplistic** (MFHM)<br>Characterised by non-complex characters or strokes |  |
| **Simulated/ simulation** (MFHM)<br>An attempt to copy or reproduce writing or a signature. | |
| **Size/size relationship** (MFHM)<br>The dimensional associations within and between handwritten characters. |  |
| **Skill** (MFHM)<br>How well an individual is able to produce and repeat the formation of handwritten characters. | |
| **Slant/slope** (MFHM)<br>The angle or offset that the handwriting is produced at, relative to the baseline. |  |
| **Spacing** (MFHM)<br>The distance between characters, words or lines. |  |
| **Spatial Relationship** (MFHM)<br>The height or width relationships between characters, words or lines of writing. | |
| **Speed** (MFHM)<br>How fast the writing is produced. | |
| **Spurious** (MFHM)<br>In relation to signatures: one created without the apparent use of a model or template such that it bears no resemblance to the | Known  |

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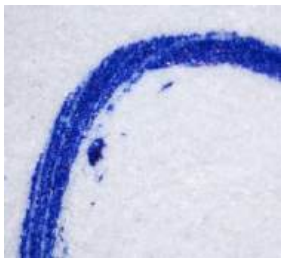
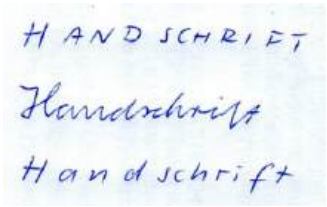
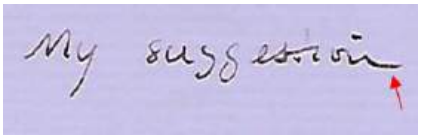
|---|---|
| genuine signature. May also be referred to as fabricated. | Questioned  |
| **Striation marks** (MFHM) Fine voids in the ink line of a ballpoint pen caused by obstructions between the ball and housing wiping the ink off the ball. These can be used to determine pen direction. |   |
| **Structural Features** (MFHM) Features relating to the construction of handwriting e.g. number, position, order and direction of strokes. | |
| **Style** (MFHM) The overall pictorial design of the handwriting e.g. printed, cursive, uppercase, lowercase. |  |
| **Substrate** (MFHM) The material that is written on, usually paper. | |
| **Tapering** (MFHM) Narrowing of the pen line due to the speed of the movement used or a lifting of the pen as a stroke is started or finished. Tapering is a characteristic that can assist in determining the speed at which a character has been produced. |  |
| **Terminal Stroke** (MFHM) The final stroke of a character or word. |  |
| **Tracing** (MFHM) Writing that is created by placing a model underneath the paper to be written on, such that the model can be observed through the paper to provide guidelines to assist in copying. | |

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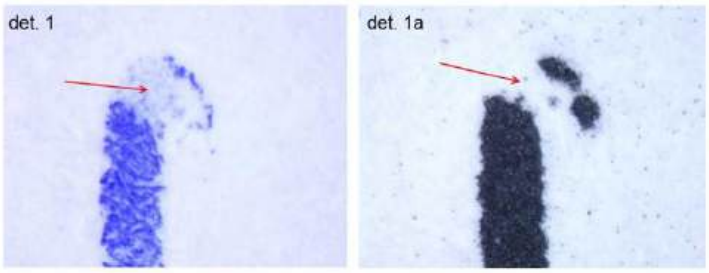
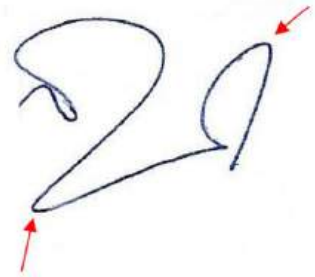
| **Trash Marks** (MFHM)<br>Remnants from the printing, scanning or photocopying process used to produce a document. They can be placed on to a document through defects or dirt in the machinery or from markings on the scanning surface. |  |
| **Tremor** (MFHM)<br>A lack of smoothness in the writing trace, due to lack of skill, deliberate control of the writing implement, or involuntary movement e.g. illness. |  |
| **Turning Points** (MFHM)<br>Position at which a pen line changes direction. |  |
| **Unnatural**(MFHM)<br>A movement that is forced or difficult to execute. Unnatural writing is seen when a person is trying to disguise their own writing, or trying to simulate that of another writer. Some characteristics of unnatural writing movements include slow speed, low fluency, stops or pauses in the pen line or blunt endings and beginnings. | |
| **Variation** (MFHM)<br>Having one or more forms of a character or word in a naturally of handwriting. | |
| **Writing Implement** (MFHM)<br>Any tool used to create a handwritten marking on a substrate. Typically however, used to describe the use of a pen, pencil, marker or crayon to create words on paper. | |

| | |
|---|---|
| **Writing Surface** (MFHM)<br>The underlying surface that a substrate (e.g. paper) is placed on whilst handwriting is produced. The writing surface will impact on the pictorial qualities of the writing and can impose a limitation on comparisons. | |

## ABBREVIATIONS

| | |
|---|---|
| ACE-V | Analysis, Comparison, Evaluation and Verification |
| CE/PT | Collaborative Exercises and Proficiency Tests |
| DCS/DCH | Digitally captured handwritten signature/handwritten entry |
| FHE | Forensic Handwriting Examiner |
| Kn | Known material |
| LR | Likelihood ratio |
| QA | Quality Assurance |
| Qn | Questioned material |

1

# APPENDIX A – AMENDMENTS AGAINST PREVIOUS EDITIONS

| | Approved Date | Details of Amendment |
|---|---|---|
| 1 | 07 Dec 2015 | Issue of original Best Practice Manual |
| 2 | 30 June 2018 | Appendix 3 – Addition of new paragraph relating to Signatures in Section 9.3.1.7<br>Appendix 3 – Addition of new Section 10 dealing with Assessment, Interpretation and Reporting<br>Appendix 4 – Multiple changes to layout and content to reflect content of the Documentation of Forensic Handwriting Method: A Modular Approach – Version 2016 (MFHM).<br>Appendix A – Amendments to the Appendices |
| 3 | 15 October 2020 | General – The document is now referred to by Edition number rather than Version number.<br>BPM – Addition of additional three paragraphs in the Scope detailing differences in FHE and Graphology<br>Appendix 1<br>Appendix 3<br>Appendix 5 – completely new section to the BPM |
| 4 | 22 September 2022 | This edition of the Best Practice Manual has been significantly changed and restructured with several new Appendices added. There have been some amendments to small parts of the previous text, including a slight adjustment in the title of the BPM. |
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