Best Practice Manual for the Forensic Examination of Handwriting

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ENFSI wishes to promote the improvement of mutual trust by encouraging forensic harmonisation through the development and use of Best Practice Manuals.
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Official language
The text may be translated into other languages as required. The English language edition remains the definitive version.

Further information
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Best Practice Manual for the Forensic Examination of Handwriting

CONTENTS

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 the Forensic Examination of Handwriting). 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 accommodation requirements for the forensic examination of handwriting.

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 and 17020 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 signatures by comparison with a set of known 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 the Forensic Examination of Handwriting”.

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 the Forensic Examination of Handwriting" 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, not exceeding 12 months (for example with the use of collaborative exercises or proficiency tests).

4.2 Equipment

The principle equipment required for Forensic Handwriting Examination is a suitable form of magnification (such as a stereo-zoom microscope).

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.

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 Accommodation and environmental conditions

The principle considerations for forensic handwriting examination are the need for sufficient, secure work space 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 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 volume of 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 examination of handwriting, 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.

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 checks. 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 written record of these checks should be made on the case notes, bearing the signatures 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 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 examination of handwriting 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 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
- 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 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 PT/CE schemes as put together by the QCC is available at the ENFSI Secretariat. “Guidance on the conduct of proficiency tests and

collaborative exercises within ENFSI" [1] provides information for the ENFSI Expert Working Groups (EWGs) on how to organise effective proficiency tests (PTs) and collaborative exercises (CEs) for their members.

The Forensic Handwriting Examiners should participate in at least one externally generated proficiency test each year. 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 PT/CEs 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 14.1) 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 were correct and should make an assessment of the likely strength of the findings.

10. PRIORITISATION AND SEQUENCE OF EXAMINATIONS

10.1 General considerations

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

10.2 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 OF EVENTS

Not applicable

12. EVALUATION AND INTERPRETATION

When determining the authorship of a piece of handwriting and/or signature, a number of hypotheses must be considered during the evaluation and 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 of the most likely authorship of the handwriting and/or signatures.

13. PRESENTATION OF EVIDENCE

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 to the 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 Scientists 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
- 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's 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 schedules 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 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.

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Forensische Handschriftenuntersuchung. Heidelberg: Kriminalistik-Verlag, 1993

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

16. AMENDMENTS AGAINST PREVIOUS EDITION

Introduction of additional paragraphs in “Section 2. Scope” dealing with the differences between Forensic Handwriting Examination and Graphology.

See Appendix A

1

APPENDIX 1 - KEY KNOWLEDGE REQUIREMENTS FOR THE FORENSIC EXAMINATION OF HANDWRITING

SCOPE

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

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?”).

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.

DETAILED KNOWLEDGE

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

Process of handwriting comparison which includes following.

Pertaining to Analysis:

- Different writing implements
- Variations in handwriting
  - Within a piece of handwriting
  - Between two pieces of handwriting
  - Accidental variation
  - Long-term development of handwriting
- Styles of handwriting/Classification systems
  - Upper-case
  - Cursive Lower-case
  - Disconnected lower-case
  - Signatures
  - Graffiti
- Systems of handwriting
  - Different alphabets (e.g. Roman, Greek, Cyrillic, Arabic etc.)
- Determination of pen-path
- Determination of fluency
  - Variation in pen-pressure
  - Tapering ends in individual characters
  - Connectivity between characters
  - Effects of speed in handwriting
- Graphic maturity
  - Effects of complexity
  - Illiteracy

External factors affecting handwriting such as

- Writing position and writing surface

- Visibility and lighting conditions
- Motion
- Guided / Assisted hand signatures

Internal factors affecting handwriting such as

- Illness and medication
- Alcohol
- Drugs
- Handedness
- Infirmity and age
- Stress

***Pertaining* to *Comparison*:**

Effects of copying

- Freehand
- Tracing
- Transferred / Transposed signatures (e.g. photocopies)

Effects of disguise

- Types of disguise
  - Stencil
  - Fluency
- Maintenance of disguise within both known and questioned

Correct sampling techniques

- Known 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

Pertaining to Evaluation

- Considerations
  - Significance of similarities and differences
  - Chance resemblance
  - Simulation
  - Disguise
  - Limited populations
  - Class characteristics (foreign writing)
  - Individual/ class characteristics
- Bayesian Approach/Likelihood ratios

Different styles of conclusion scales in common usage

- Certainty of conclusions and probabilities

Grouping - management of large cases

Presentation of evidence
- Orally
- In written format

Contamination

GENERAL AWARENESS

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

Teaching methods for handwriting and taught styles

Graphology – a discipline where the personality of an individual is inferred from their handwriting. It is to be clearly distinguished from forensic handwriting examination. This type of examination is not supported by this BPM (see section 2. “Scope”).

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 Merrill 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 OF 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 Examination of Handwriting").

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 the Forensic Examination of Handwriting" (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 personal 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 timescale

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 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.

Handwriting examinations – Training Programme

Name: James Smith

General information

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

Activity		Training Time	Target date	Completion	
				Trainee	Trainer
External influences	• Disguised handwriting • Copying and forgery • Effects of drugs and alcohol on handwriting • Effects of illness and age on handwriting • Writing with the unaccustomed hand • 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 • Review of casework material • 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 (assuming that a "signature" machine has not been used).

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 4.

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 Expert 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 required to undertake a 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

- Guidelines for Best Practice in the Forensic Examination of Handwriting
- Appendix 1 - Key Knowledge Requirements for the Forensic Examination of Handwriting
- Appendix 2 - Training Requirements for Forensic Handwriting Examiners
- Appendix 4 - Terminology used in Forensic Examination of Handwriting

9. PROCEDURE

9.1 The flow diagram 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

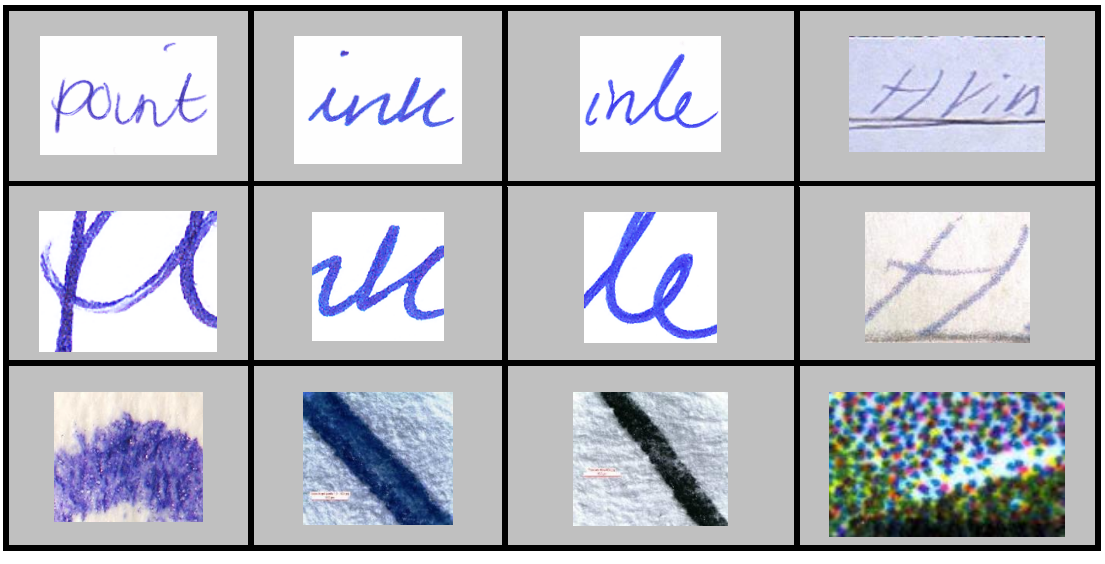
[Note: The effects seen are used for comparison purposes only and while it may be possible to give a limited, advisory comment on the physical state of an individual, an FHE can draw no inference on the mental state of an individual on the basis of the handwriting characteristics.]

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 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.)
- Type of ink (for example ball point pen, liquid ink or gel ink etc.)



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

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

- Colour

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 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.

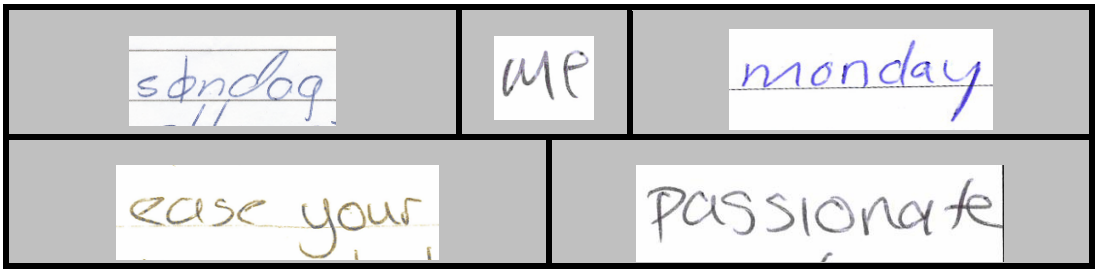


Fig 3. Examples of different pieces of disconnected lower-case handwriting

- 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

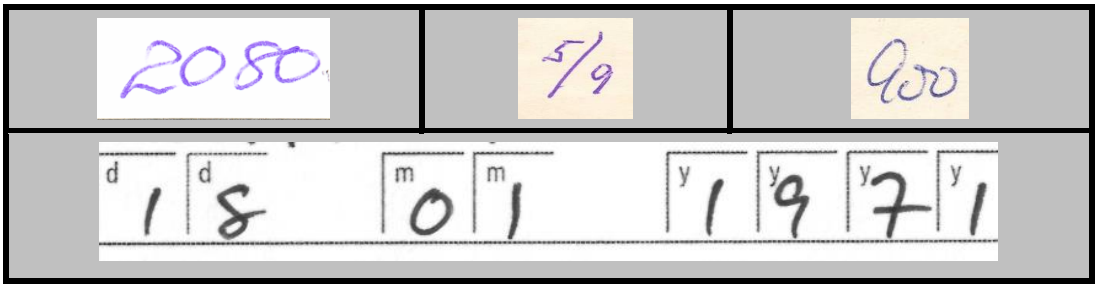


Fig 6. Examples of numerals

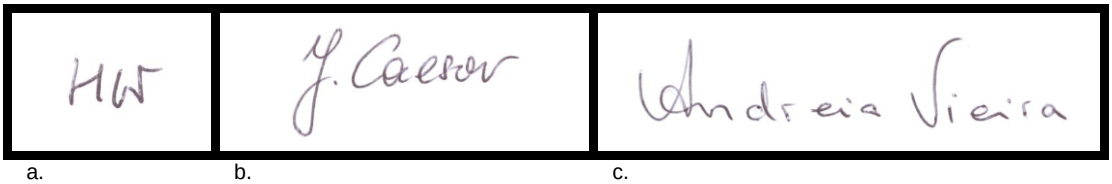
- Graffiti – like signatures a particular type or style of handwriting which has it own unique requirements when being examined. [**Note**: Caution needs to be taken when examining this type of handwriting]

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 a 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 legible or stylized, 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

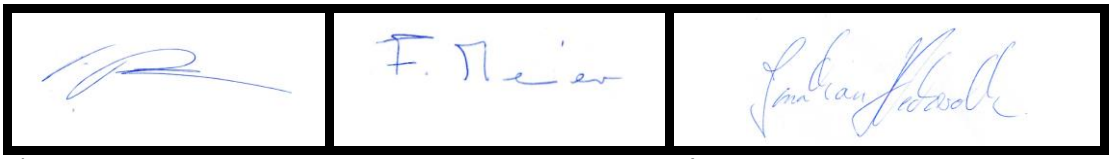
the lower the likelihood of a chance match. The images below represent different styles of signatures ordered by length and complexity.

Legible signatures



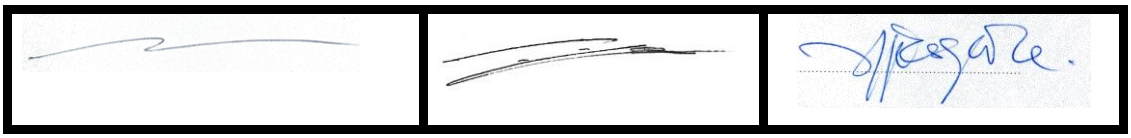
a. b. c.

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. The lack of legibility, especially in signatures, is often encountered.

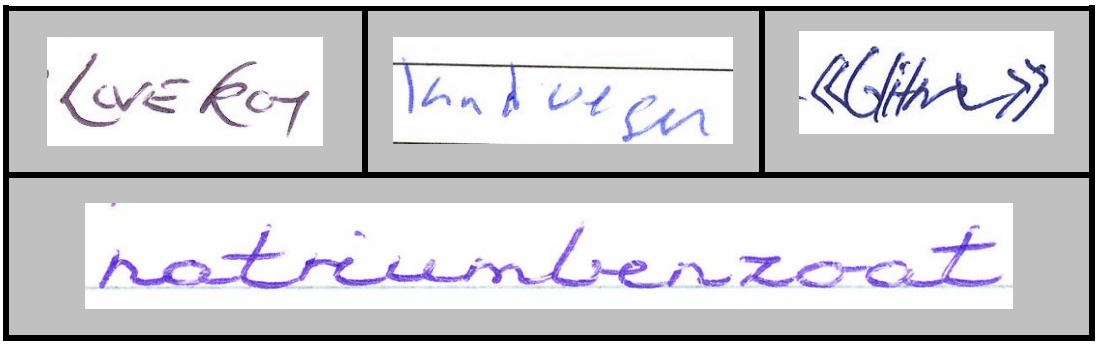


Fig 9. Examples of both legible and illegible handwriting

- 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.

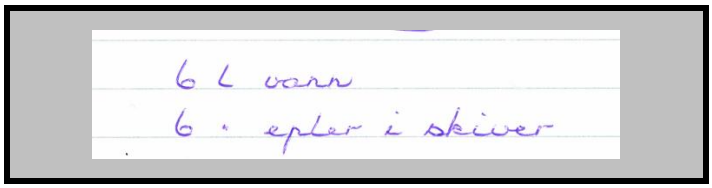


Fig 10. Images showing relative height of handwriting compared with printed lines.

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

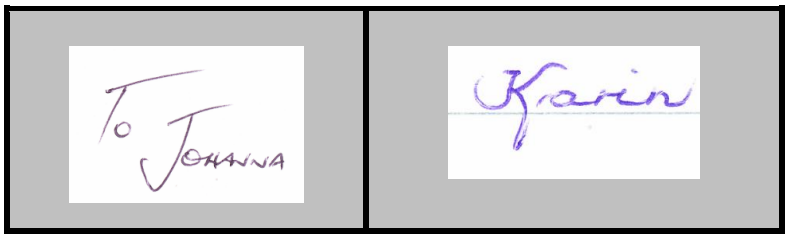


Fig 11. Two pieces of handwriting showing distinctly different sizes to characters within words.

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

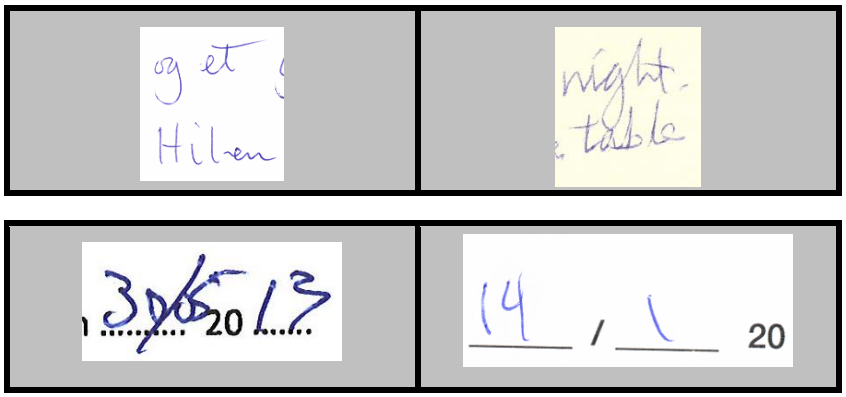
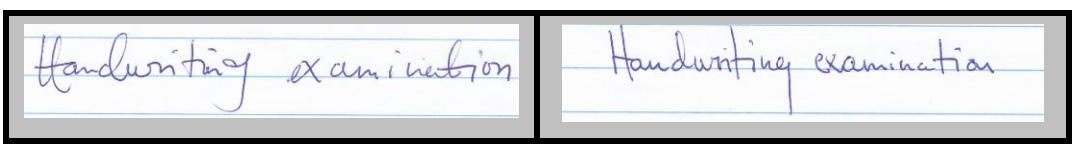


Fig 12. The effect of limited space on handwriting as well as examples of spacing in routine handwriting.

- 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)



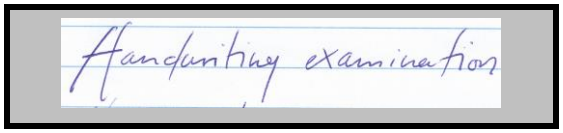


Fig 13. Three examples of handwriting. All produced by one person showing the effects of altering the slope of the handwriting.

- 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

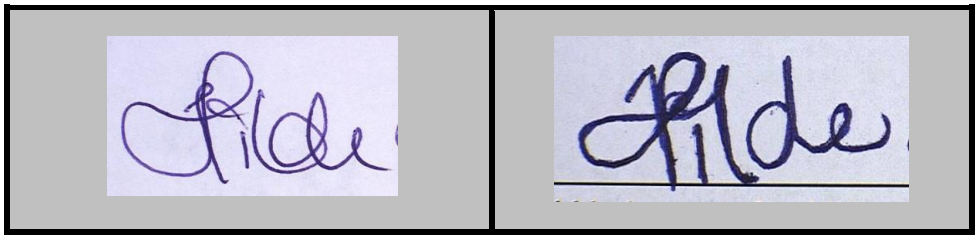
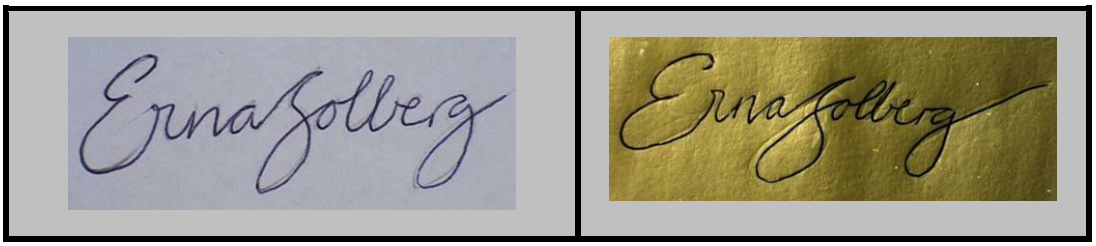


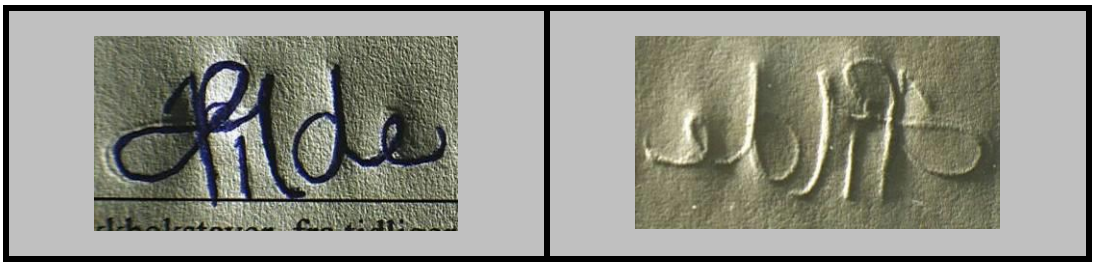
Fig 14. Images showing the differences in fluency between two words. The left hand image shows connective strokes, tapered ends and variation in pen pressure, the right hand image lacks these features.

- 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.

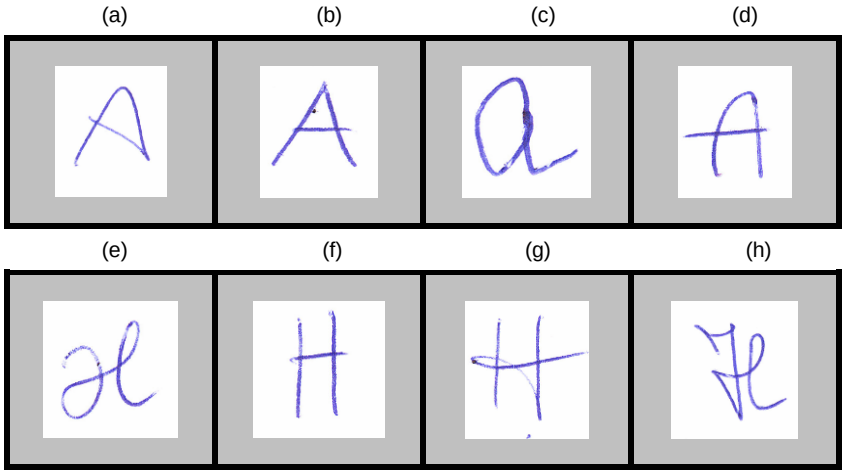


Fig 17. Images (a) to (d) show four different block capital ‘A’s produced by the same person. The same person produced the range of ‘H’s shown in images (e) to (h).

- 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.

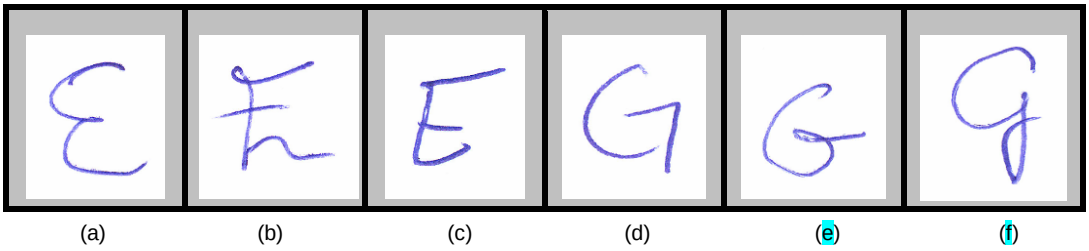


Fig 19. Images (a), (b) and (c) show three different constructions for an upper-case ‘E’, whilst images (d), (e) and (f) show variations in the pen-path for the letter ‘G’.

- 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.

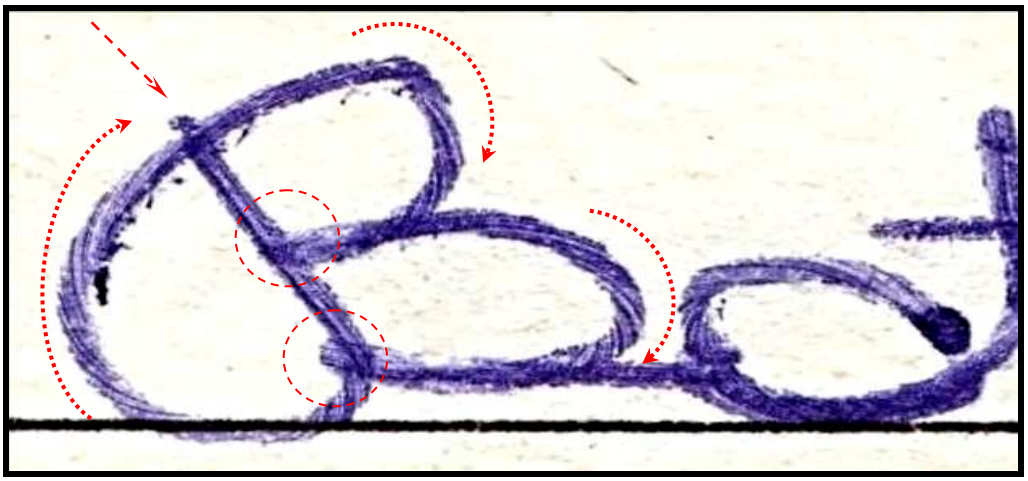


Fig 20. Images showing the various different components to the initial character in a word.

- 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 positons between two words.

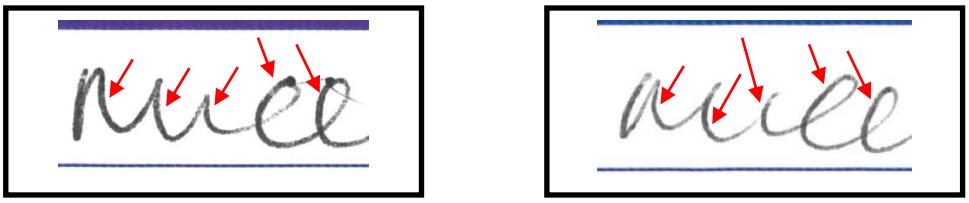


Fig 21. Images showing the variation in pen pressures, at the same points, between a questioned signature (left) and genuine signature (right).

9.6 Similarities and differences between writing

9.6.1 Features to be noted, and compared, include:

- *Quantity and quality of handwriting*
  Note similarities and differences in the quantity and quality of the handwriting (see Section 9.3)

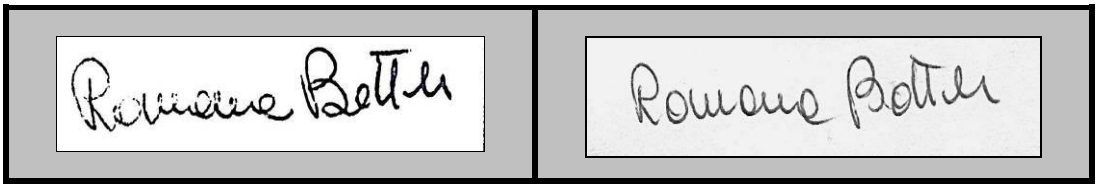
- *General Characteristics*
  Note similarities and differences between the General Characteristics (see Section 9.4)

- *Character types*
  Note similarities and differences between the character types (see Section 9.5). Features to be assessed include character shape, proportions, structure, as well as character combinations etc.

9.7 Examination of copy documents

9.7.1 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.

9.7.2 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 ASSESSMENT, INTERPRETATION AND REPORTING

10.1 On completion of the examination there is a detailed assessment of the relevant findings for their significance. These findings will include the:

- Quantity and quality of handwriting (see section 9.3).
- General Characteristics (see section 9.4).
- Results of the Detailed Examination (see section 9.5).

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

10.3 Once assessed a conclusion is formulated using the relevant conclusion scale

11. QUALITY ASSURANCE AND COMPETENCY

11.1 A competent examiner should be able to use the Instrumentation listed in Section 7.

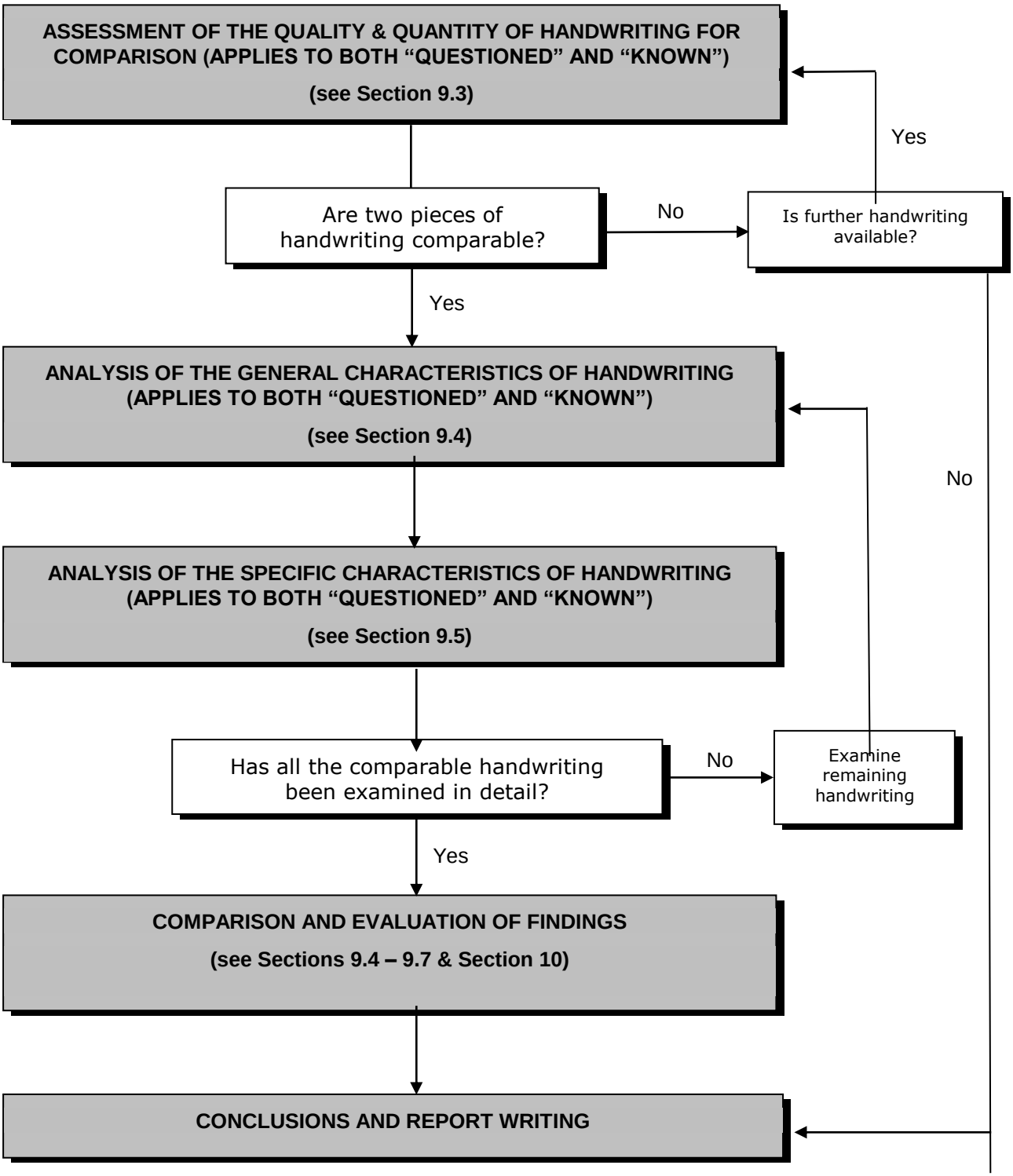
11.2 The competencies relevant to the Examination and Comparison of Handwriting are summarised in the Key Knowledge Requirements for Forensic Handwriting Examination.

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

12. REFERENCES

12.1 There are many books, journals and individual papers published on the subject of Handwriting Examinations. It is impossible to compile a complete list of all of these. The principle books are detailed in Section 15 of the Guideline for the Best Practice in Forensic Handwriting Examinations.

SCHEMATIC REPRESENTATION OF THE EXAMINATION AND COMPARISON OF HANDWRITING



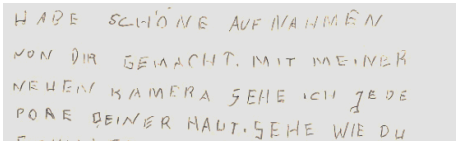
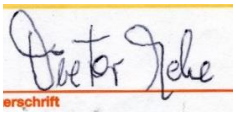
APPENDIX 4 - TERMINOLOGY USED IN THE FORENSIC EXAMINATION OF HANDWRITING

SCOPE

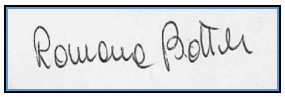
The following list, although not exhaustive, includes many of the basic terms used in the examination of handwriting and signatures. The bulk of these terms have come from the Modular Forensic Handwriting Method– Version 2016 (MFHM).

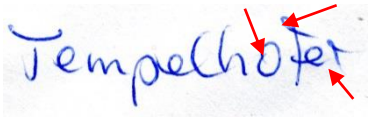
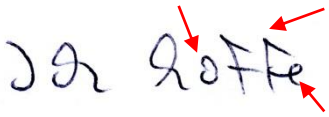
Term	Illustration
Accidental (MFHM) An unusual feature or characteristic, deemed to be unintentional, not seen in the bulk of the handwritten material.	
Allograph (MFHM) A particular design of a character, where there can be more than one design per character e.g. capital letter A is a different allograph than a cursive letter *a.*	
Artefacts (MFHM) Remnants. For example, trash marks are artefacts of a copying process; writing is an artefact of human movement.	
Authentic (MFHM) When a document/ handwriting is genuine.	
Authorship The process of writing a document.	
Baseline (MFHM) The real or assumed line upon which handwriting is produced.	
Chance match (MFHM) 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) Letters, numbers and symbols; graphemes.	

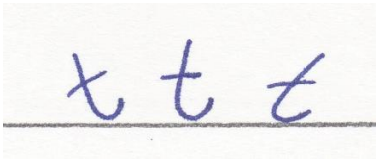
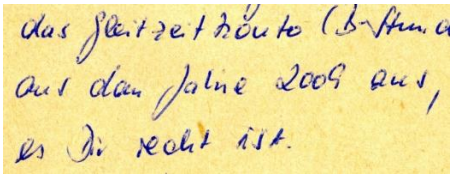
Collected Specimen (MFHM) Samples of a known person's handwriting/ signatures that have been produced throughout the course of day-to-day business and have been collected by the investigator for the purposes of comparison against questioned material. Examples include letters, diaries, business records, forms or cheques. These can also be known as normal course specimen or course of business specimens.	
Common Authorship (MFHM) 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) Material that is suitable for comparison e.g. similar style, case.	
Complexity (MFHM) A combination of speed, style and construction; how difficult the writing is to simulate.	
Concatenations (MFHM) Connections.	
Connections (MFHM) The union of two characters e.g. in cursive writing.	
Consistent (MFHM) Similar, regular throughout a passage of writing or between multiple signatures.	
Construction (MFHM) How a character, word or signature has been produced, including features of number, direction and sequence of strokes.	
Copybook style (MFHM) A writing book of letters printed for imitation and used in schools as a teaching pad / a book, used in the past by children in school, containing examples of writing which school students had to copy.	

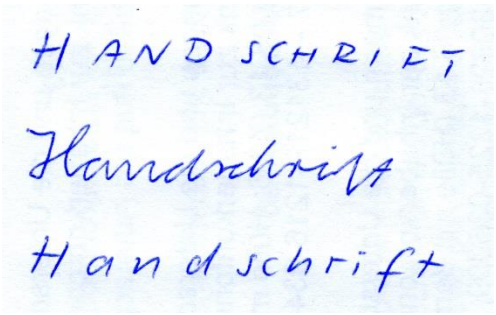
Disguise (MFHM) A deliberate attempt to hide normal writing habits.	
Dissimilarities (MFHM) Differences between writings.	
Drag (pen drag) (MFHM) A very fine ink stroke where the writer has not completely lifted the pen from the surface of the page between strokes.	
Embellishments (MFHM) Flourishes added to the writing.	
Excluded (MFHM) Material that is not examined.	
Feature (MFHM) An aspect of a character or the handwriting in general.	
Flourish (MFHM) An ornamental or exaggerated pen stroke.	
Fluency (MFHM) The speed and skill level of the writing.	Fluent  Non-fluent 
Forgery (MFHM) Non-genuine writing.	
Formation Variation (MFHM) Differences in the method of constructions of a character.	
Fundamental Difference (MFHM) A repeated difference in the questioned material that is significantly different to the specimen material.	
Grapheme A single unit or character in a writing system (a, b, c, A, B, C, 1, 2, 3 etc)	

Guidelines (MFHM) 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) The size differences within and between handwritten characters.	
Indented Impressions (MFHM) Markings or imprints on the paper surface caused by the pressure of a writing instrument on the pages or paper above.	
Inter-comparison (MFHM) Comparison of handwriting on more than one document or by more than one writer.	
Legible (MFHM) Decipherable or readable material.	
Limitation (MFHM) A constraint to the examination, comparison or opinion formation process e.g. non-original documents, limited quantity of material.	
Line Quality (MFHM) 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 (MFHM) The memory for motor skills that controls movements such as that of the hand during the writing process.	
Movement (MFHM) The motion of the writing stroke.	
Natural Variations (MFHM) Normal or usual deviations that occur in repeated specimens of a person's handwriting.	
Nexus (MFHM) A connection or link.	

Non-Original (MFHM) Reproduction of a document e.g. photocopied, faxed, scanned, photographed.	Original  Non-original 
Normal Behaviour (MFHM) 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) Writing over other writing.	
Pause (MFHM) A temporary interruption to a stroke without removing the writing instrument from the writing surface.	
Pen Direction (MFHM) The direction the pen moves to produce a character, connection or signature.	
Pen Lift (MFHM) An interruption in a stroke caused by removing the writing instrument from the writing surface.	
Pictorially consistent/similar (MFHM) Having a similar shape, allowing a more detailed examination to take place (in relation to signatures).	
Pictorially inconsistent/ dissimilar (MFHM) Having a dissimilar shape, meaning no further comparison can take place (in relation to signatures).	
Preliminary Examination (MFHM) An initial examination preceding the main examination; giving initial observations regarding the ability to examine the items in question.	
Proportion (MFHM) The height and spatial aspects within or between characters.	

Proposition (MFHM) A statement or outcome to be tested during examination. There are generally two opposing propositions to be tested: 1. The same writer produced A and B 2. Different writers produced A and B	
Questioned (MFHM) Handwriting or signatures about which the authenticity or authorship is in doubt.	
Repeated Difference (MFHM) Differences between writings that are seen consistently throughout the passages of writing.	
Requested Specimen (MFHM) Specimen samples written specifically for the purpose of comparison to questioned material (as requested by an investigator).	
Retouching (MFHM) To add lines or strokes in order to correct, improve or alter.	
Signature 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.	 Barack Obama
Similarities (MFHM) Having mutual resemblance and a number of features in common.	Item 1  Item 2 
Simplistic (MFHM) Characterised by non-complex characters or strokes	
Simulated/ simulation (MFHM) An attempt to copy or reproduce writing or a signature.	
Size/size relationship (MFHM) The dimensional associations within and between handwritten characters.	

Skill (MFHM) How well an individual is able to produce and repeat the formation of handwritten characters.	
Slant/slope (MFHM) The angle or offset that the handwriting is produced at, relative to the baseline.	
Spacing (MFHM) The distance between characters, words or lines.	
Spatial Relationship (MFHM) The height or width relationships between characters, words or lines of writing.	
Specimen (MFHM) Proven samples of handwritten material from a nominated person, used to compare against the questioned handwriting.	
Speed (MFHM) How fast the writing is produced.	
Spurious (MFHM) In relation to signatures: one created without the apparent use of a model or template such that it bears no resemblance to the genuine signature. May also be referred to as fabricated.	
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.	
Trash Marks (MFHM) 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) 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) Position at which a pen line changes direction.	
Unnatural(MFHM) 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) Having one or more forms of a character or word in a naturally of handwriting.	
Writing Implement (MFHM) 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) 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.	

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APPENDIX 5 – 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[1] 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[2] 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 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

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[1] 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.

[2] 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.

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[3] are registered (tab. 1):

- *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.

Tab 1. Example of DCS data

Point (sampling moment)	X-coordinates	Y-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

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

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.

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.

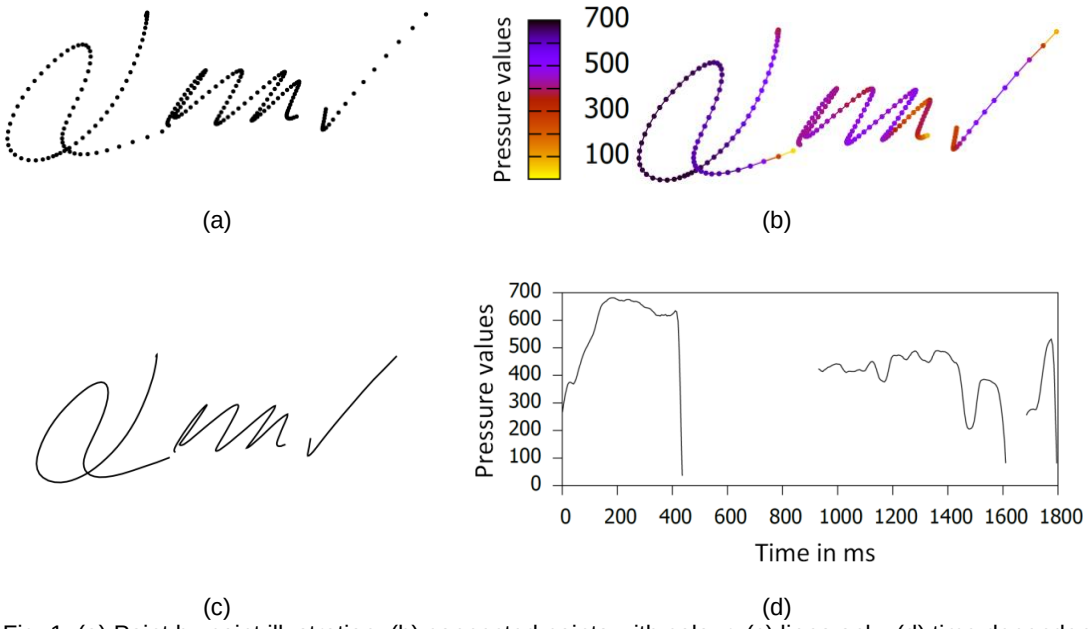


Fig. 1. (a) Point by point illustration, (b) connected points with colour, (c) lines only, (d) time dependent graph.

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. 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, which means that it needs to be decrypted first. The mandating authority should ask the DCS capturing solution administrator to decrypt the signature using a relevant key, ideally in presence of the expert, or to provide the required files and information for decryption.

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 diagram shown at the end 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.

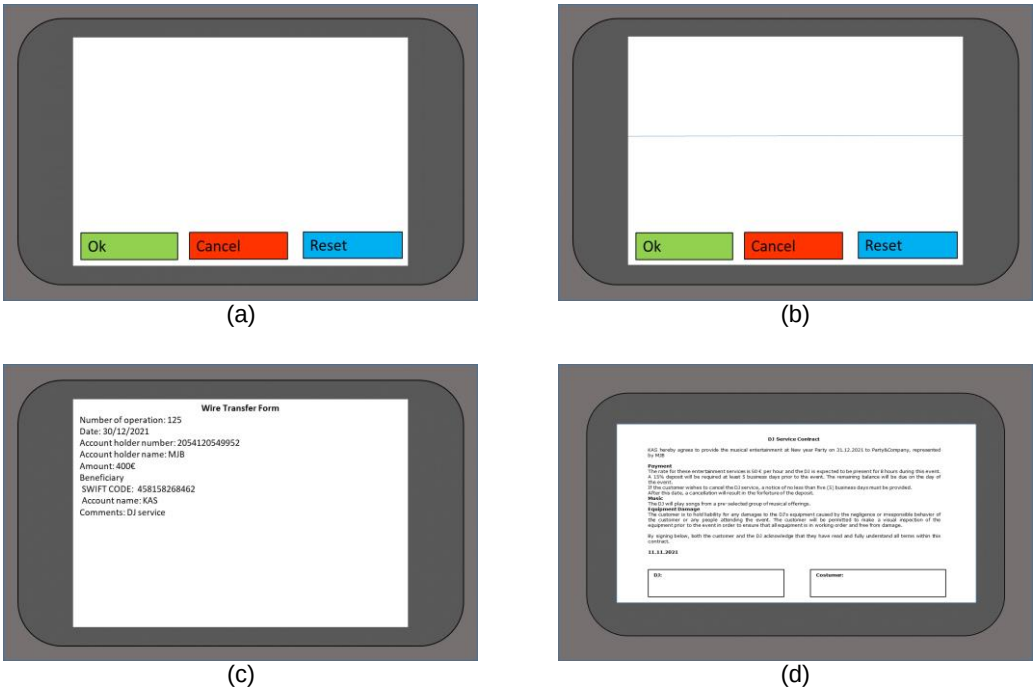


Fig. 2. (a) No visual information on the active area, (b) single line as visual information on the active area, (c) example of intense visual information projected on the signature pad for a bank transaction, (d) example of visual information projected on the entire screen and selection of a specific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

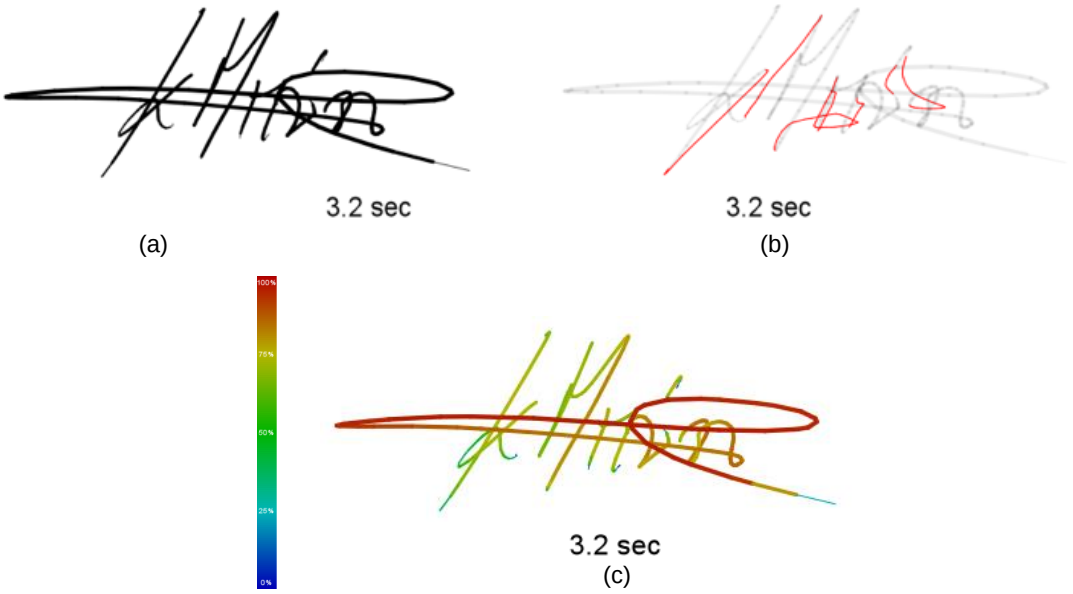


Figure 3. (a) Linear representation, (b) air movement representation and (c) pressure representation of a genuine signature.

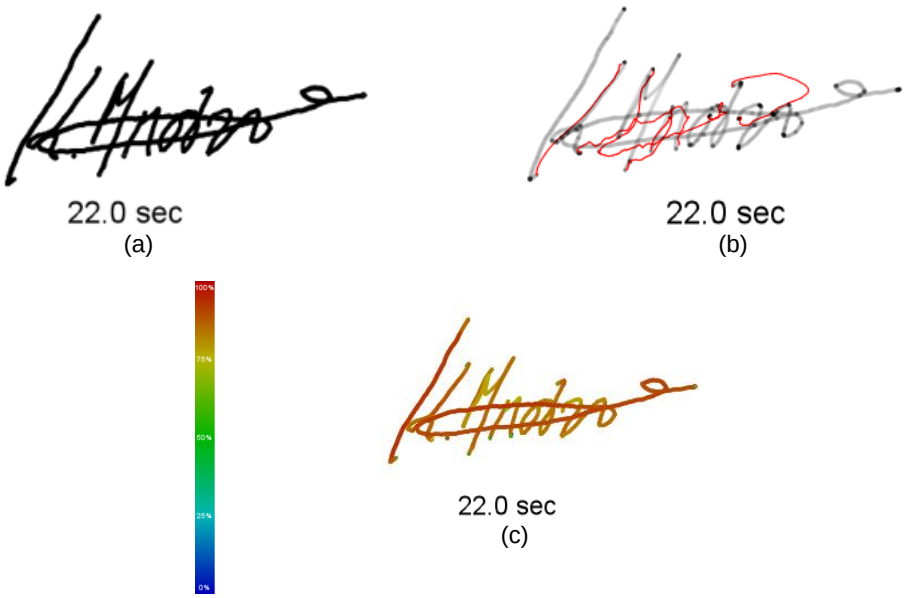


Figure 4. (a) Linear representation, (b) air movement representation and (c) pressure representation of a traced forgery. Note the difference in the time of execution of this traced signature (22.0 s), when compared to the genuine signature in Figure 3 (3.2 s).

- 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.

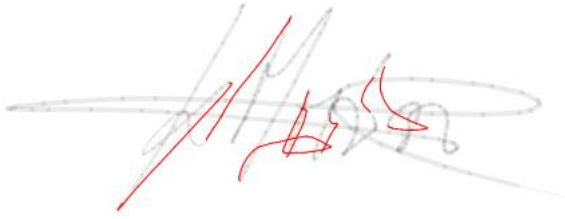
- Air movements trajectory (air strokes)
  Trajectory of the pen in between contact (strokes) may be significant and may exhibit a unique pattern (see figure 5). This should be observed and compared (if applicable). The following considerations must be taken into account when examining air movements:

  - 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).

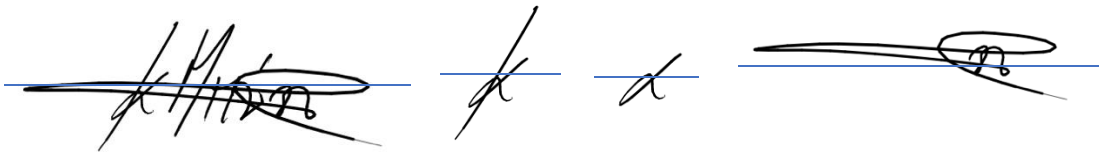


Fig. 6. Segmented analysis of a complex signature by isolating parts of the signature through selection of points recorded.

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.

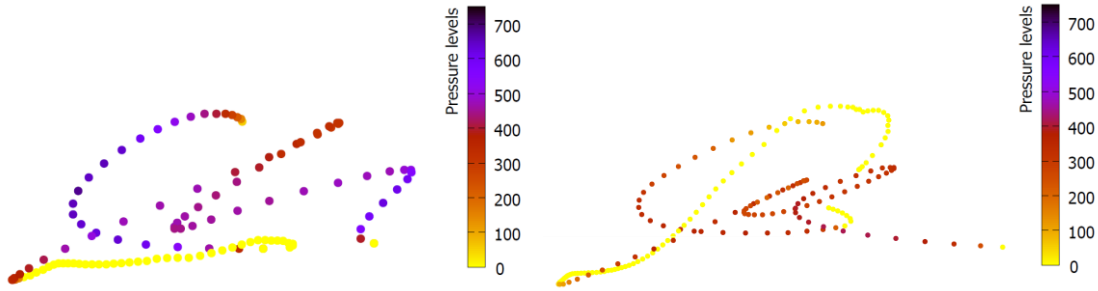


Fig. 8. Representations of DCSs showing the data points (X- and Y-coordinates) in different colours, according to the recorded pressure levels. Air movements are shown in yellow (pressure level 0).

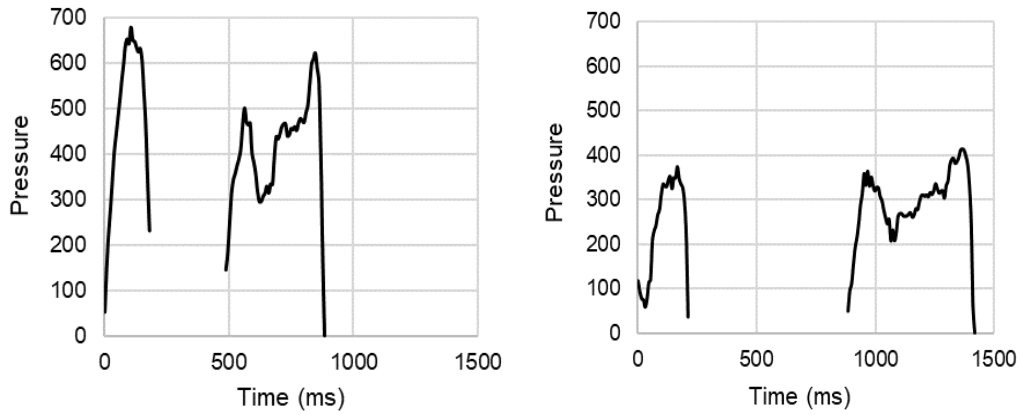


Fig. 9. Pressure time plots showing the pressure level in function of execution time.

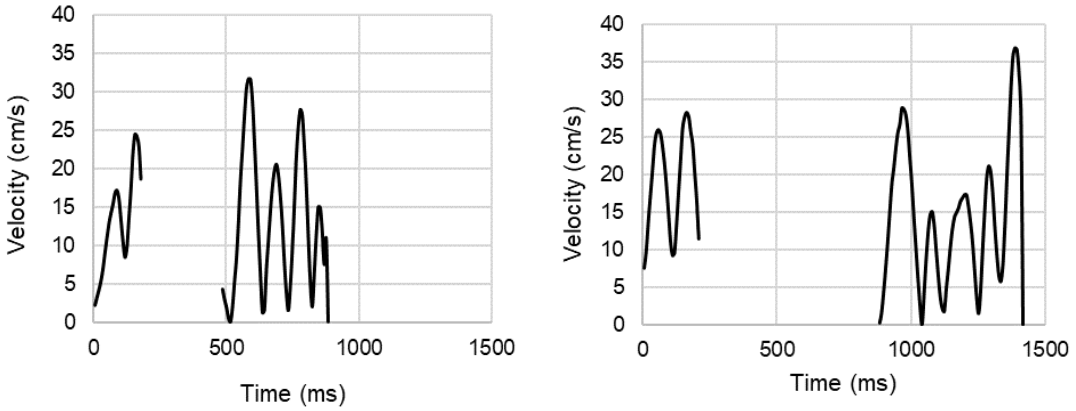


Fig. 10. Velocity time plots showing the calculated velocity in function of execution time.

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.

11. REFERENCES

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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Mohammed, L. A., Found, B., Caligiuri, M.P., & Rogers, D. (2010). The dynamic character of disguise behavior for text-based, mixed, and stylized signatures. *Journal of Forensic Sciences, 56*, 136–141.

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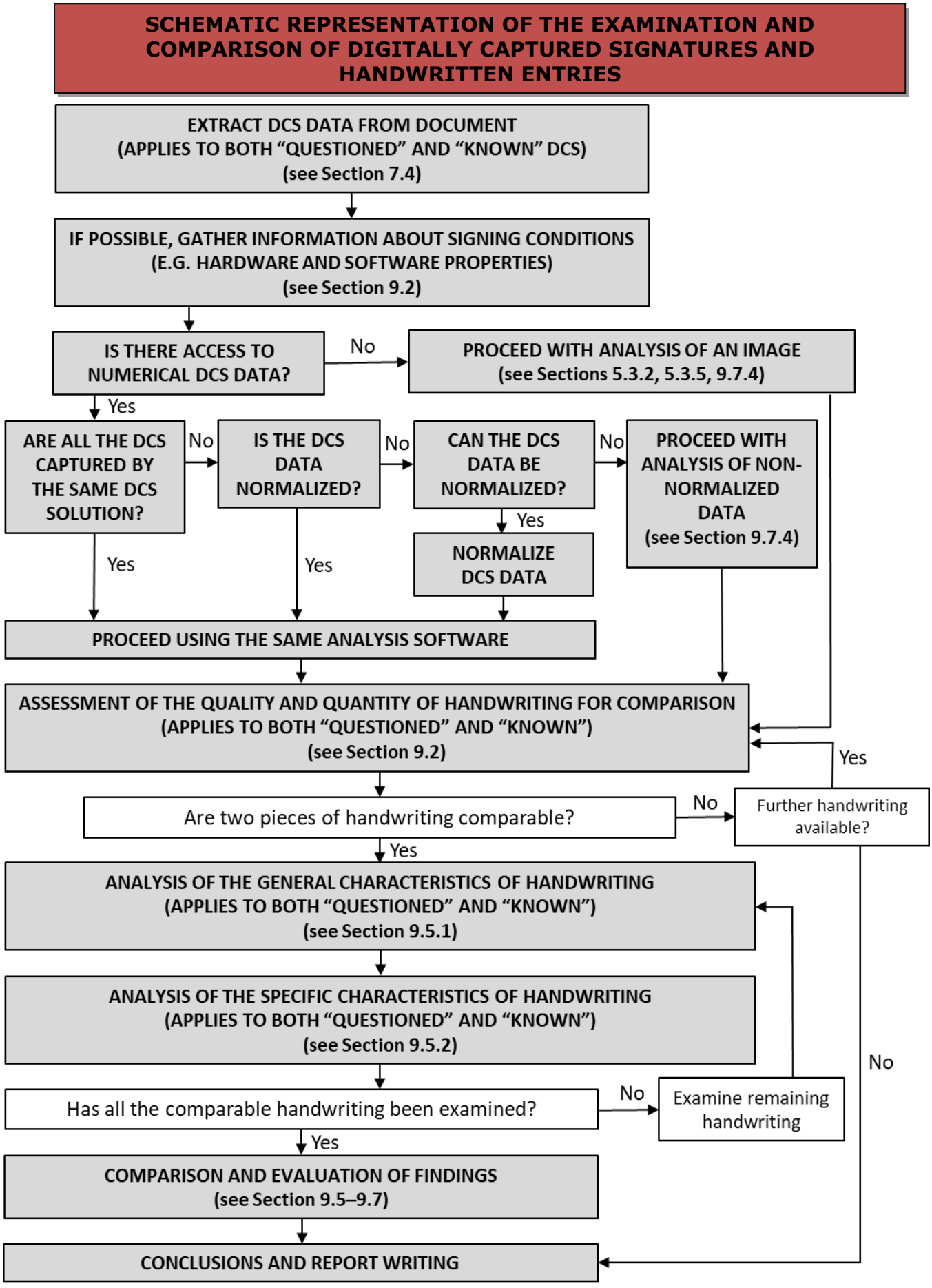
SCHEMATIC REPRESENTATION OF THE EXAMINATION AND COMPARISON OF DIGITALLY CAPTURED SIGNATURES AND HANDWRITTEN ENTRIES
EXTRACT DCS DATA FROM DOCUMENT (APPLIES TO BOTH "QUESTIONED" AND "KNOWN" DCS) (see Section 7.4)
IF POSSIBLE, GATHER INFORMATION ABOUT SIGNING CONDITIONS (E.G. HARDWARE AND SOFTWARE PROPERTIES) (see Section 9.2)
IS THERE ACCESS TO NUMERICAL DCS DATA?
No
PROCEED WITH ANALYSIS OF AN IMAGE (see Sections 5.3.2, 5.3.5, 9.7.4)
Yes
ARE ALL THE DCS CAPTURED BY THE SAME DCS SOLUTION?
No
IS THE DCS DATA NORMALIZED?
No
CAN THE DCS DATA BE NORMALIZED?
No
PROCEED WITH ANALYSIS OF NON-NORMALIZED DATA (see Section 9.7.4)
Yes
NORMALIZE DCS DATA
Yes
Yes
PROCEED USING THE SAME ANALYSIS SOFTWARE
ASSESSMENT OF THE QUALITY AND QUANTITY OF HANDWRITING FOR COMPARISON (APPLIES TO BOTH "QUESTIONED" AND "KNOWN") (see Section 9.2)
Yes
Are two pieces of handwriting comparable?
No
Further handwriting available?
Yes
ANALYSIS OF THE GENERAL CHARACTERISTICS OF HANDWRITING (APPLIES TO BOTH "QUESTIONED" AND "KNOWN") (see Section 9.5.1)
ANALYSIS OF THE SPECIFIC CHARACTERISTICS OF HANDWRITING (APPLIES TO BOTH "QUESTIONED" AND "KNOWN") (see Section 9.5.2)
Has all the comparable handwriting been examined?
No
Examine remaining handwriting
Yes
No
COMPARISON AND EVALUATION OF FINDINGS (see Section 9.5–9.7)
CONCLUSIONS AND REPORT WRITING

APPENDIX A – AMENDMENTS AGAINST PREVIOUS EDITIONS OF THE APPENDICES

	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 Appendix 3 – Addition of new Section 10 dealing with Assessment, Interpretation and Reporting Appendix 4 – Multiple changes to layout and content to reflect content of the Documentation of Forensic Handwriting Method: A Modular Approach – Version 2016 (MFHM). Appendix A – Amendments to the Appendices
3	15 October 2020	General – The document is now referred to by Edition number rather than Version number. BPM – Addition of additional three paragraphs in the Scope detailing differences in FHE and Graphology Appendix 1 Appendix 3 Appendix 5 – completely new section to the BPM

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