Best Practice Manual for Forensic Image and Video Enhancement

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ENFSI's position on Best Practice Manuals

ENFSI wishes to promote the improvement of mutual trust by encouraging forensic harmonisation through the development and use of Best Practice Manuals.
Furthermore, ENFSI encourages sharing Best Practice Manuals with the whole Forensic Science Community which also includes non ENFSI Members.
Visit www.enfsi.eu/documents /bylaws for more information. It includes the ENFSI policy document Policy on Creation of Best Practice Manuals within ENFSI (code: QCC-BPM-001).

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The S-FIVE project and the core BPM team was formed by the following researchers and investigators: Dr. Patrick De Smet (S-FIVE Project Leader, NICC/INCC - Belgium), Simon C. Latham (MPS - UK), Stefan Ott (main BPM author, BKA - Germany), Dr. Neil Cohen and Dr. Luke Scarth (CAST - UK), Sotiris Pavlides (CSCP - Cyprus), Dr. Zeno Geradts and Dr. Arnout Ruifrok (NFI - The Netherlands).

Official language
The text may be translated into other languages as required. The English language version remains the definitive version.

Further information
For further information about this publication, contact the ENFSI Secretariat. Please check the website of ENFSI (www.enfsi.eu) for update information.

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ABBREVIATIONS

CCTV	Closed Circuit TeleVision
CE	Collaborative Exercise
DIWG	Digital Imaging Working Group (ENFSI)
DVR	Digital Video Recorder
EWG	Expert Working Group
FITWG	Forensic Information Technology Working Group (ENFSI)
FIVE	Forensic Image and Video Enhancement
IEC	International Electrotechnical Commission
ILAC	International Laboratory Accreditation Cooperation
ISO	International Standardisation Organisation
JPEG	Joint Photographic Expert Group
PT	Proficiency Test
QCC	Quality and Competence Committee (ENFSI)
QMS	Quality Management System
ROI	Region Of Interest
SOP	Standard Operating Procedure

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 evidence. 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 Image and Video Enhancement (FIVE) that will deliver reliable results, maximize the quality of the information obtained and produce robust evidence. The use of a consistent methodology and the production of comparable results will facilitate the interchange of data between laboratories.

This BPM is aimed at experts in the field and assumes prior knowledge in the discipline. It does not aim to be a Standard Operating Procedure (SOP) and addresses the requirements of the judicial systems in general terms only. This BPM provides guidance for the development of a set of SOPs covering the whole process of Forensic Image and Video Enhancement.

The term Best Practice Manual is used to reflect the scientifically accepted practices at the time of writing. The term BPM does not imply that the practices laid out in this manual are the only good practices to be used in the forensic field. In this series of ENFSI Practice Manuals the term BPM has been maintained for reasons of continuity and recognition.

2 SCOPE

This document addresses various types of issues concerning the forensic process for enhancement of digital image and video evidence from the scene of crime to the presentation of evidence in court, and encompasses the specific aspects related to resources, validation, methodology, quality assurance, case assessment, etc. for the whole spectrum of the forensic process.

This BPM concentrates on the technical aspects of digital image and video data enhancement. The scope of the manual is limited to field specific guidance and does not include the more general concepts of digital evidence or evidence in general, like general handling of evidential material, chain of custody, contamination issues, secure archiving of digital data, etc.
The input data for the enhancement process should be valid digital image or video files, i.e., the material to be enhanced should be readily viewable; e.g., the repair of corrupt files or carving of file fragments is out of scope of this manual. The manual deals with authentication issues as far as that is necessary to clarify the provenance (see Section 5.2 and 9.3), but (technical) authentication methods for digital image and video data are out of the scope of this manual. Digitization of analogue video and imagery is also out of the scope of this document.

The results of a FIVE process are digital images and videos that are better suited for the Customer’s purposes, together with comprehensive documentation to record what has been done (Audit Trail). The material could be used as evidence in court or serve as an input for other forensic examinations that relate to, e.g. identification or comparison of persons or objects, or determining measurements of parameters like person height or vehicle speed.
This BPM does not include discussion or guidelines for any of these subsequent applications.

This BPM is accompanied by a digital supplement [ENFSI S-FIVE BPM Supplement] that tries to fill the gap between the high level, often rather abstract rules of a BPM formulated according to the guidelines of the ENFSI Quality and Competence Committee (QCC), and the much more detailed considerations needed to write SOPs for units performing FIVE.

3 DEFINITIONS AND TERMS

For the purposes of this BPM, the relevant terms and definitions given in ENFSI documents, the International Laboratory Accreditation Cooperation (ILAC) G19 “Modules in a Forensic Science Process” [ILAC G19:08/2014], as in standards like ISO 9000, ISO 17000 and 17020 apply.

The following definitions and terms have been used throughout this document:

Archiving – Long-term storage of digital data, possibly determined by legal requirements

Audit Trail – Documentation of case work

Codec – Coding and decoding software for digital image and video data

Compression – The process of changing the coding method to reduce the size of data. See also Lossy and Lossless Compression

Conversion – Changing the representation (coding and/or file format) of digital image or video data. If the coding of the imagery is altered via conversion image quality loss may occur. Conversion may also influence the amount or type of metadata that is encoded. The output of a conversion step is termed a ‘Converted Image’ or ‘Converted Video’.

Copy – A 1:1 (bit-identical) copy of a digital image or video file. If a verification step has confirmed that the copy of the data is identical it is termed a ‘Verified Copy’.

Customer – A person or body requesting a FIVE activity to be undertaken

Digital Image – Digital data which represents a matrix of brightness or colour values and metadata (optional).

Digital Video – Digital data which represents a sequence of recorded digital images of the same pixel size and metadata; audio data may be included

Examiners – All persons engaged in (not purely administrative parts of) FIVE examinations

Expert – Person providing fact and opinion evidence in reports and in court

File Format – The structure by which data is organized in a file

First Copy Image – The first laboratory generated (verified) copy of the submitted digital image material

First Copy Video – The first laboratory generated (verified) copy of the submitted digital video material

Image – In this document used as abbreviation for digital image

Image Analysis – The extraction of information (either qualitative or quantitative) from digital image data beyond that which is readily apparent to a layperson through visual examination

Image Enhancement – Any process intended to improve the appearance of specific detail within a digital image or video in respect of an intended purpose and use

Image Operation – Image processing function

Image Processing – Any activity which uses digital image or video data (input, source) to compute new digital image or video data (output, result)

Image Processing Log – A record of the steps used in Image Processing

Inter-Frame Processing – Output frames or results computed from data drawn from multiple input frames

Intra-Frame Processing – Output frames or results computed from data drawn from the original corresponding input frame

Lossless Compression – The process of changing the coding method to reduce the size of data without any loss of information, i.e. the original information can still be retrieved in its original form

Lossy Compression – The process of changing the coding method to reduce the size of data through a loss of information, i.e. the information cannot be retrieved in its original form

Native Format – The coding and file format of the first permanently stored version of an Image or Video

Processed Image – An output Image (see Image Processing)

Region of Interest (ROI) – Part of an Image that is selected or chosen for further examination or processing

Storage – The act of preserving an Image

Storage Media – Any physical items on which digital data can be stored

Verified Copy – A 1:1 (bit-identical) copy of an Image or Video file which has successfully passed a verification step to prove that the original and the copy of the data are identical

Video – In this document used as an abbreviation for digital video

Working Copy – (Verified) Copy of a first copy Image or first copy Video which may be subjected to processing

4 RESOURCES

4.1 Personnel

For the purposes of this BPM, FIVE technical activities can be broken down into:

1. capturing/acquiring original data
2. processing or enhancement
3. reporting

A single person can perform all of these activities, but if carrying out these activities, they must be able to demonstrate up to date knowledge and experience as described below. The local Quality Management System (QMS) should clearly describe how such proof can or should be provided and documented.

Persons carrying out **capturing or acquiring** of First Copy Image and Video data should be able to demonstrate relevant up to date knowledge and experience in:

- analysis of Image and Video data structures
- export and Conversion of Image and Video data.

Persons carrying out **processing or enhancement** of Image and Video data should be able to demonstrate, for the relevant Image Operations:

- up to date knowledge and experience in Image Processing theory and practice
- a conceptual understanding of relevant Image and Video Processing algorithms and their associated parameters
- knowledge and experience in identifying and linking both visual FIVE effects and defects to potential causes such as visual effects caused by applying Image Operations (e.g., sharpening) and visual defects existing or already present in the material (e.g., motion blur).

Persons **providing fact and opinion evidence in reports and in court** (named Experts throughout this BPM) should also be able to demonstrate up to date knowledge and experience in:

- legal aspects
- presentation and written reporting issues; see also Section 13

Obviously, all persons **engaged in (not purely administrative parts of) FIVE examinations** (named Examiners throughout this BPM) should be able to demonstrate a conceptual understanding and basic knowledge in:

- general IT usage
- Image and Video data
- Image Processing theory
- demands of different evaluative tasks which need to be supported by preceding FIVE processing, e.g., facial/object comparison or identification

and up to date knowledge and experience in:

- application of legal basics and established QM rules
- practical use of the existing IT environment
- application of available Image Analysis tools
- application of available Image Processing tools

as relevant for their involvement.

4.2 Equipment

In order to be able to demonstrate reliable and repeatable casework performance, IT hardware and system software used in FIVE examinations should be set up in a well-defined and documented state. The most important components that should be considered as such for FIVE are:

- computer hardware and system software
- storage and Archiving system
- graphics system and its Codecs, Video/2D/3D acceleration features and colour settings
- graphical output devices like displays and printers
- graphical input devices like scanners and frame-grabbers (if the input from analogue sources is included)

Examiners and experts should be aware of the technical risks and issues related to the use of these basic components. Laboratories should balance the theoretical considerations against the practical feasibility of exhaustive technical and risk assessment and management strategies, and especially focus on those issues that are most relevant for the types of examinations undertaken.

Laboratories should also consider issues concerning the accuracy of displaying and any reproduction of digital imagery when carrying out FIVE related activities (e.g. brightness and contrast, colour balance and calibration, colour temperature, gamma, gamut).

There is a wide range of classes of software that can be used in FIVE. The most prominent classes are:

- specific FIVE software
- general purpose Image Processing tools
- general purpose Video editing tools
- general data analysis tools
- Image and Video data analysis tools (file structure/metadata and Image statistics)
- general and manufacturer-specific viewers

A lot of tools can only be used safely for FIVE purposes in a strictly controlled manner. SOPs and validation reports (see Section 6) for software and/or functions should give guidance on which software should be used to realize a specific function on given source data.
More information about software suitable for FIVE purposes, methods and example Images can be found on the ENFSI S-FIVE Homepage (www.s-five.eu).

In consideration of

- the enormous diversity of Image and Video data structures and features
- the high complexity and dependencies of the numerous system components
- the high frequency of new software versions and updates
- Image Processing systems (or subcomponents) firmware updates

it is absolutely impossible to guarantee that the desired output representation (as intended by the original recording device manufacturer) can be obtained for any possible source Image or Video. Therefore it is important for FIVE laboratories to have well-documented solutions for performing checks and documenting suboptimal performance of software and hardware infrastructure. This solution (e.g., a database of non-conformance issues) can serve to provide warnings for all personnel, and inform them about correct usage. Such a solution should also provide the ability for all personnel to access historical non-conformance logs.

In light of these matters, it may be advisable to divorce such technical details from any main SOPs, but still complement, or, effectively complete, these SOPs with reference to actively maintained documents concerning technical issues and suboptimal performance, non-conformance logs, and their solutions.

If applicable, for equipment required to be calibrated, the relevant SOPs should describe the calibration procedure and the reference material to use.

4.3 Reference materials

Reference materials may be used for performing tests concerning the transparency of a system; i.e. by using a reference signal or data input one can check for any types of degradation occurring in the processing pathway by observing the system output (See [ENFSI S-FIVE BPM Supplement] for examples).

In FIVE casework, reference materials are typically used for comparison of structural and statistical features (to check provenance) or visual effects of certain processing steps. A comparison of processing results obtained for evidence Images to those obtained for one or more reference Images, may yield indications about possible causes and solutions for Image deficiencies (e.g. to correct for barrel distortion, a distortion of an Image due to properties of optical lenses, a reference Image produced by the recording device can be used to determine appropriate compensation).

4.4 Accommodation and environmental conditions

FIVE activities require little or no Image and Video specific accommodation and environmental conditions, except for:

- the general rules for IT laboratories should be applied; see [ENFSI FIT WG BPM]
- special consideration should be given to lighting conditions (e.g., positions of building windows and artificial light sources vs. computer screens, etc.), heating/air conditioning (e.g., equipment overheating and staff health), confidentiality of display content (passers-by, positioning of displays and desks), and ergonomics (e.g., properly installed desks, displays, chairs, etc.)

When drafting FIVE SOPs a technical risk analysis for these issues should be carried out.

4.5 Materials and Reagents

There are no Image or Video specific technical specifications for materials; the general rules for digital evidence apply [ENFSI FIT WG BPM].

Reagents are not used in FIVE.

5 METHODS

5.1 Peer Review

Human-based estimates often play a central role during the whole process of Image and Video enhancement. Therefore peer review is a useful method to improve objectivity and increase reliability of results. Its use should not necessarily be limited to the final check; peer review can be used during the whole process and should be used for all critical steps and according to the examiner's needs, if it is expected that an impact on the (quality of the) obtained result may occur.
If the Customer needs additional examinations like facial image comparison or fingerprint comparison based on the FIVE results, participation of an appropriate additional expert in the relevant application domain might lead to further FIVE improvements and higher confidence. However, in this case the risk of introducing bias into the FIVE processes may need to be evaluated and additional peer review should be considered. This should be considered especially if the non-FIVE expert would have also been assigned investigative responsibilities or be otherwise engaged with the case under consideration.

5.2 Analysis, Compatibility and Consistency checks

For all data items a suitable viewer or FIVE software should be obtained and used, so that visual output can be delivered that has a quality that is in line with expectations of the Examiner as appropriate for the examination. Metadata and other relevant features of the data should be crosschecked against the reported provenance, and any discrepancies should be examined, assessed, explained, resolved as far as possible, and documented. If any doubts about the authenticity of the data arise (e.g., manipulation or falsification of provided data), the Customer should be contacted and a separate more detailed investigation regarding these issue may be required (as indicated in Section 2, the discussion of Image and Video authentication methods falls outside of the scope of this BPM).

It should be noted that the availability of such viewer tools may not always be straightforward (e.g., due to the use of proprietary equipment or Codecs). As noted in Section 2.2 this BPM assumes that these tools are available. Some additional comments with respect to this issue are included in the [ENFSI S-FIVE BPM Supplement].

5.3 Selection

During the FIVE processes a lot of selection steps might be necessary:

- selection of the most promising source Image(s)
- selection of the most suitable tools
- selection of the most promising enhancement methods and their relevant parameters
- selection of the most promising parameter values for these enhancement methods
- selection of resulting Images, in general and/or for reporting

SOPs should reduce this high variability by developing more concrete rules out of the general principles, general conditions and restrictions as defined by the laboratory, and by also considering the proportionality in terms of the available resources versus the possible impact on results (i.e., carrying out a risk analysis).

5.4 Single Image Processing

5.4.1 Selection of single Image Operation

Input Images for single Image Operations can be First Copy Images or Video frames or any already obtained intermediate results. Starting from the intended use and the deficiencies of an input Image, the most promising Image Operation should be selected from amongst those available. This Image Operation is expected to be able to deliver the best desired effect without unacceptable side effects and with minimal losses elsewhere (in the Region of Interest, ROI). The examiner needs to form a clear idea about which features are enhanced and which other features may be flawed or impacted by those enhancements. Additional discussion about restrictions and limitations for concatenation of operations can be found in the supplementary remarks [ENFSI S-FIVE BPM Supplement].

5.4.2 Choice of parameters

Many Image Operations have one or several parameters, including, e.g., the number of iterations (if the algorithm works iteratively) and the region to which the Image Operation is applied. Parameters typically control properties like radius of neighbourhood, strength of effects or weighting functions. A typical method to get the best parameter vector is to adjust values successively under visual quality control using sliders, which works best if the Image Operation can be computed fast enough. Sometimes parameters are not independent, which makes finding the optimal values more difficult; independent parameters can be optimized separately, dependent parameter sets have to be adjusted in an iterative process. The sensitivity of resulting Image qualities to parameter changes may vary. Some parameters show only moderate effect over a broad range of values, others deliver good results only in a very narrow band and show an unstable behaviour elsewhere. Examiners should know about these different parameter characteristics and should verify this behaviour in each specific occurrence. If testing lots of parameter sets is too resource and/or time consuming, alternatives could be to estimate parameter values using:

- measurements in the Image or in a transformed version (e.g. estimating the radius of focus blur, or the length and angle of motion blur by examining prominent features or object edges in an Image)
- a smaller region, e.g., a sub-sampled or cropped Image, and switch back to the original ROI when an optimum is found. It should be noted that it may be necessary to adjust relevant parameters if sub-sampling was used
- a faster algorithm which delivers inferior quality but works fast enough to allow interactive parameter optimisation

Often there is not one optimal parameter that gives the best result; rather there may be different parameter sets which give results that are optimal for a specific examination or for highlighting a specific feature. In general, low degrees of enhancement preserve the overall impression of the scene, while high degrees of enhancement may deliver more details. However, such results may then no longer yield accurate results for or representations of the whole scene. Details about handling and reporting of parameter sets can be found in Section 5.7.

Examiners should consider that some tools may restrict both the range of values that can be selected for certain parameters, and/or the availability of parameters themselves. Algorithms, coding formats, etc. may also not be implemented correctly or consistently across different manufacturers. Finally, Image Processing algorithms may implicitly rely on several important algorithmic issues such as the methods used for handling non-available Image data (e.g. processing of pixels near Image, ROI or windowing borders), numerical conversion and computational accuracy issues (data types used for internal representation of pixel data), etc.

Some of these issues and their possible solutions are discussed in more detail in [ENFSI S-FIVE BPM Supplement].

5.4.3. Selection of number of iterations

Iterative Image Processing algorithms need a number of computation cycles. Some software user interfaces ask for this number in advance or use a default value. Typical iterative methods show an increase in Image quality first but end up with decreasing quality. This behaviour guarantees the existence of an optimal number of iterations (for a given parameter set) which has to be determined. Whenever possible the complete sequence of intermediate results should be checked to identify the optimal result, and the sensitivity of the result to these parameter variations should be examined. In most cases storage of the optimal result will be sufficient. If the dependence on a parameter value is important, then a sequence of results, with variations of that parameter, can be stored. Some additional comments about (reporting on) parameter dependencies can be found in Section 5.6.

5.4.4 Use of ROIs

If an Image Operation is applied to a selected ROI, that region must be clearly documented and, if needed, reported on. Different non-overlapping ROIs in one resulting Image are allowed, as long as each of the ROIs can be assigned to the different Image Operation settings and are clearly documented for the Customer.
It should be noted that some methods may (implicitly) make use of ROIs to train or determine (initial) parameter settings; e.g., in a filter a certain area may be used to sample noise characteristics.

5.4.5 Adaptive Operations

Image Operations may be locally adaptive, guiding the local impact on the pixel values of the resulting Image (e.g., noise remover, image enlargement or zooming in using interpolation).
In this case the results must be presented in conjunction with the First Copy Image, and a description giving an impression of what kind of adaptation has taken place should be provided.
A similar rule must hold if a series of Image Operations using varying parameters produces a series of intermediate results and an additional step fuses these Images into one final resulting Image. A more intensive discussion of frame fusion and super resolution can be found in Section 5.5.

5.5 Image Sequence Processing

5.5.1 Interlacing check

Still a lot of Video and Image sequence data show interlacing effects (two Video fields, taken at different times, are intertwined row by row to form a complete Video frame). For each Video and Image sequence the examiner must know, whether interlacing effects are present or not, and use this knowledge to choose appropriate processing methods. Details about this matter can be found in [ENFSI S-FIVE BPM Supplement].

5.5.2 Intra-Frame Processing

Single Image Operations can also be applied to Image sequences. Some tools may provide for each of the parameters, an option allowing the user to specify whether the same value should be used for all images, or if the parameter(s) should be automatically adjusted for each image. Using the same setting for all frames minimises the effort, but may cause perceptible losses if the processing of some of the Images needs other parameters to get optimal results.

5.5.3 Inter-Frame Processing

An additional possibility is to analyse the relation of Image content between different frames of a sequence. The results of motion analysis allow: the computation of stabilised Image sequences which are easier to evaluate by a human observer, and the collection of visual information about an object from different frames in order to fuse it into a single Image. The computation of displacement vector fields at sub-pixel precision should be considered as this may deliver better and higher resolution fusion results (super-resolution).

Motion analysis introduces new parameter choices, e.g.:

- selection of a set of Images which are sufficiently similar (often the tools are bounded to fixed size temporal neighbourhoods of a frame)
- selection of an object or region of interest
- selection of the motion estimation method
- selection of a regularisation method (because local motion information may be unreliable)

Motion analysis processing is rather complex and the capabilities depend heavily on the available tools. A SOP describing the application of motion analysis in FIVE should be based on the technical documentation of the tools in use.

5.6 Typical General Processing Strategy

Typically, a FIVE process will start with the best footage which needs simple processing, and then proceed onto lower quality inputs with more demanding needs. This process will stop when the Customer needs can be fulfilled or when it becomes clear that there is no suitable solution. Additionally, it is advisable to:

- try out different tools and/or Image Operations if the quality of a result is crucial for the success, compare the results, including the analysis of the sensitivity of those results to variations of any possible parameter values or other factors that may impact those results, and choose the best one.
- Always check the results of the filter/processing output against the expected theoretical outcome. If necessary, another/better specialist for the tool or problem at hand should be consulted, and/or the plausibility of the given genesis information should be checked again

5.7 Documentation

All records generated during the course of FIVE examinations must be in accordance with the requirements of the local legal system, and the local quality management system. They should also provide sufficient detail to allow another competent examiner to evaluate the quality and reliability of the work and to repeat any part of it, using the same Image processing environment. The examiner should keep contemporaneous notes detailing the versions of software used, source and resulting Images, methods and processing settings. Sole use of modern FIVE software offering extensive logging and replay capabilities minimizes the additional manual effort; project files make permanent storage of these records an easy task. If a multitude of tools needs to be used, the examiner has to collect the different sources of records and add sufficient documentation.
As indicated in Section 5.4 consideration can also be given to documenting results by providing a sequence of different results, e.g., obtained for variations of certain parameter settings.

6 VALIDATION AND ESTIMATION OF UNCERTAINTY OF MEASUREMENT

6.1 Validation

The minimum requirements for considering a method validation in FIVE are:

- definition of an IT-environment
- definition of a class of possible input sources
- definition of a task
- detailed description of the process (in which order which tools and functions are used)
- collection of rules to ensure that known errors and flaws of the used tools do not adversely affect the results and that the quality of results is optimised according to the given conditions
- a set of examples, covering the range of allowed sources and typical Customer requirements sufficiently well

A validation report documents the processing of all examples using the method and provides guidance to choosing the most suitable solution whenever more than one possibility is described. If the processing was successful for all examples in the set, the method is called fit for the intended use.

Using validated methods raises trust in the quality of results, but cannot guarantee optimal or even error-free results. Whenever expectation and results show differences, a deeper examination of the causes is necessary and, if not case specific, the affected parts of the description of the method have to be readjusted. This continuous improvement process is part of the overall QMS which has to account for the consequences and impact on former results too; i.e., a laboratory performing FIVE should perform an adequate risk analysis and implement a proper procedure for handling the discovery of any inconsistencies, human or software errors that might be present in current, intermediate, and past results.
The (more general) aspect of “feedback to the Customer” is also discussed in Section 9.1.2.3.

6.2 Estimation of uncertainty of measurement

Usually it is difficult, if not impossible, to provide a quantitative value of uncertainty for any given FIVE result.

Thus, whilst it can be accepted that within FIVE examiners and experts 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
- 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.

The following is a list of where uncertainty can arise in FIVE examinations:

A Human factors; e.g., training, competency and proficiency testing, (in)accurate use of procedures, (lack of) peer review, restrictions in resources, communication issues, etc.

B Impossibility of being certain that the (replay) hardware, firmware, device drivers, software (updates) and operating system (updates) are all functioning correctly, including (combinations of) installed system Codecs, etc.; see also Section 4.2

C File formats and algorithms and their implementations, as well as related numerical inaccuracies; see also Section 5

D Potential parameter settings, the order of Image Operations, and limitations for concatenation of Image Operations; see also Section 5

E Quantitative measures for evaluating and/or comparing results not being available; see also Section 7

F Storage media and data transfer; see also [ENFSI FITWG BPM]

As already indicated in this Section and also in Sections 5.3 and 5.6, (un)certainty can thus be demonstrated and/or documented, either in general or for any specific case, by providing a sequence of different results, e.g., obtained for variations of certain parameter settings. There are however cases where it may be possible to communicate more clearly that uncertainty may exist, for instance when presenting the enhancement of a number plate and interpreting specific letters; see [ENFSI S-FIVE BPM Supplement].

7 PROFICIENCY TESTING

Proficiency Tests (PTs) should be used to test and assure the quality of Image and Video Enhancement processes.
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” [ENFSI QCC-PT-001] provides information for the ENFSI Expert Working Groups (EWGs) on how to organise effective Proficiency Tests (PTs) and Collaborative Exercises (CEs) for their members.

It should be noted that PTs relate to both the laboratory processes and competency of personnel within the laboratory. As a side effect, PTs may point out errors or discrepancies in SOPs.

Quantitative quality measures for resulting Images are not available in general; a ranking according to a number of subjective ratings is the most promising solution for this problem.

The FIVE team in the laboratory should participate in PTs on a regular basis according to the requirements of the QMS. Each test should cover major aspects of FIVE casework and the whole range of aspects should be covered over time. If the external PTs are not sufficient, participation to CEs and additional internal tests can widen the coverage. As already indicated above, more information about any available CEs can be obtained from the ENFSI Secretariat or the ENFSI Digital Imaging Working Group.

Participants in any test should always follow the laboratory’s/unit’s standard procedures for casework. They should not give the test any special treatment that would not be given in the same circumstances to casework.

8 HANDLING ITEMS

8.1 At the scene

There are no Image and Video specific considerations for handling items at scenes; the general rules for digital evidence apply [ENFSI FITWG BPM]. However, a more detailed discussion about issues that could be resolved by proper evidence processing at the scene is given in Section 9.1.

8.2 In the laboratory

SOPs that cover handling of items have to guarantee integrity of the original data. The recommended method is to store original 'First Copy' data read-only in an initial reference directory and use working copies (1:1 copies), stored in a working directory for further processing. The success of the copy operation can be checked, e.g., by full file comparison or comparison of (low "hash collision" rated) hash values of the original data and the Copy. Processed or altered files should be renamed in an appropriate way; data files should not keep their original names, even if stored in another directory than the original file.
More details about secure handling and long term Archiving can be found in the references included at the end of this document.

9 INITIAL ASSESSMENTS

9.1 General aspects

9.1.1 Introduction

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 possible alternative(s), thus mitigating the effects of bias.

9.1.2 Establishing the Customer Requirement

9.1.2.1 *Purpose*

It is essential before starting any examination in the laboratory to understand, or agree with the Customer, the purpose of the examination requested. Preferably this should be carried out by an intermediate party to prevent bias by the FIVE examiners. The requirements should be expressed in terms of what the Customer is seeking to establish rather than a menu of tasks to be carried out.

9.1.2.2 *Protocol*

A protocol should be in place therefore to determine:

- what is the purpose of the (initial) enhancement request
- the Customer's priorities for the information requested
- what other information is or may be available from the Customer
- what is the most suitable way of presenting the results (e.g. prints, stills, Video, password protected access)
- what constraints may exist (e.g., preservation of material for other purposes such as fingerprint examination, DNA, custody time limits, cost, further examinations based on the results, etc.)
- privacy and security requirements (data protection/anonymization/masking).

9.1.2.3 *Feedback Loop*

It is important to have in place a two-way continual or iterative process of communication as new information may come to light or requirements may change before, during or as a result of scene or laboratory examinations. Issues that may affect the requirement or priorities will include:

- changes in the direction of the investigation
- changes in the status of suspects and victims
- changes in the urgency for information
- new and significant information coming to light
- the impact of results already reported
- discovery of flaws in the processes performed prior to the FIVE examination
- discovery of flaws in the FIVE examination process

New information about features of devices, algorithms or methods used, as well as the discovery of flaws in FIVE processes and their effects on (intermediate) results has to be communicated to and discussed with the Customers of the affected current cases. Procedures to assess the severity of these issues, and the necessity to inform Customers of former, already finished FIVE examinations have to be performed according to the general rules of the QMS.

9.2 Assessment at the scene

The general rules for assessment of digital evidence have to be applied. However, there is one exception which should be specified by FIVE SOPs: i.e., the export of Image and Video data from a Digital Video Recorder (DVR) Closed Circuit Television (CCTV) system or any other fixed imaging systems should be documented in detail. Taking these systems as a whole from the site to the laboratory is another possibility which might be attractive to minimize risks.

Additionally, the following example issues should be considered and addressed at the scene:

- time and date settings, time zone settings, frame rate, interlacing and all other system settings
- unreliable export functions, performing (lossy) recoding of Video data and/or stripping or separate recording of important metadata
- verification of the acquired evidence (e.g. download), e.g., to ensure it corresponds to the correct time period and cameras, and that the data has not been corrupted and that such corruption will not go undetected later on (during transfer or due to storage media issues etc.). This may also relate to chain of custody issues (hashing, secure time stamping of data)
- lack of player supplied with download (possibly remedied by collecting system and vendor details), or default use of unknown or non-standard Video Codecs
- password protection and encryption issues (system, storage media, exported data, etc.)
- state of internal battery (will time and date be reset when disconnecting power?)
- erasure due to timed and/or automatic expiry, or accidental or malicious actions
- unexpected behaviour after changing hardware components (e.g., a CCTV DVR clone hard disc being seen as a new hard disc by the system possibly causing a (re) formatting operation)
- ...

It is important to note that this list should not be thought to be exhaustive and that any additional issues may require detailed attention, possibly also on a case by case basis. As noted in Section 4.2 proper consideration and procedures should be realized for handling and learning from any technical and non-conformance issues.

Valuable sources of more guiding information to develop an SOP are the guidelines of the Scientific Working Group on Imaging Technology (SWGIT, USA) Video and [ENFSI FIT WG BPM] for general assessment of digital evidence and data; see Section 15.

Sufficient documentation of the details of the assessment process is necessary in order to establish reliability prior to carrying out successive processing steps.

9.3 Assessment at the laboratory

9.3.1 Preliminary Technical Assessment

An assessment should be made to establish what is technically possible and what is worthwhile in order to meet the Customer requirements.

9.3.2 Documentation Check

Submitted case documentation should be checked. Ideally documentation should be complete with respect to the chain of custody, the retrieval and previous Image Processing steps carried out, and be traceable to the individual carrying out these steps. If insufficient information is provided, the Customer should be informed about the possible effects or impact of the findings.

9.3.3 Purported Provenance/Quality Check

The purported provenance of the material should be assessed. Is the footage consistent with its purported origin? (Generic Formats such as Video DVD, *.avi file, etc. should be questioned because exporting or copying Video from media often includes a recoding process which can have severe impact on the quality of the Video frames).
If the footage does not appear to be consistent with its purported origin, the Customer should be contacted and a clear strategy for resolving these issues should be implemented.
Similarly, a strategy should be devised for handling cases for which no or limited assessment of the provenance can be obtained or verified.

Reasonable steps should always be taken to obtain the earliest available version of the Image or Video material. If there is the possibility that higher quality data can be obtained from the Customer, then this possibility should have higher priority than any application of more sophisticated processing of the given data.

9.3.4 Image Input Quality Criteria

FIVE laboratories may define minimum Image input quality criteria for certain use cases and use it for pre-evaluation, to determine if pursuing further processing is actually sensible. Communication of such rules to the Customers may help in repulsion of obvious unpromising examinations. There are some important points to consider in using such criteria:

- minimum Image input quality criteria are always and inseparably tied to the aspired further use, e.g., identification of license plates, facial Image comparison, etc. Examples can be found in the [ENFSI S-FIVE BPM Supplement]
- the quality of single frames may not be a secure basis for making decisions; if lots of similar frames are available super resolution methods (see Section 5.5.3) may still allow Image sequence enhancements

- rules should be based on measureable and trustworthy features like the number of pixels in certain directions
- every rejection based on such criteria must be communicated adequately to guarantee that the Customer can understand the reason and check whether the original formulation of the intended use was correct and complete
- local legal and QMS rules should be and remain respected.

10 PRIORITISATION AND SEQUENCE OF EXAMINATIONS

10.1 General considerations

Due to the digital nature of the data any number of independent examinations and processing steps is possible. However, as resources for processing are bounded, an optimization strategy is needed to control the selection and enhancement process. This strategy should account for:

- customer requirements, priorities and urgency (which may change over time)
- available resources: time, manpower, hard- and software, storage capacities (which may change too)
- purported provenance (see Section 9.3) and quantity of Images and Video footage to search in order to obtain the most useful source Images (FIVE triage), estimating usefulness by expected value of the expected result
- number and intensity of enhancement efforts for a single source item
- intermediate contacts with Customers and Customer feedback after intermediate results have been presented; see Section 9.1.2.3

10.2 Control strategies

The variety of situations is too broad to define an all-purpose strategy for FIVE. Nevertheless, the starting point of any examination should always be composing an initial overview of the available sources and resources, and making an assessment of potential enhancement success. Such an assessment tends to become more reliable during the enhancement process and normally stabilizes when the enhancement process is stopped for that source Image. This can be affected by initial and future information provided by the Customer with respect to their requirements. Peer review or parallel examinations conducted by other colleagues may be integrated into the control strategy.

11 RECONSTRUCTION OF EVENTS

Not applicable.

12 EVALUATION AND INTERPRETATION

FIVE could serve as a pre-processing step for anticipated content-related evaluation which may include evaluation and interpretation tasks, but FIVE in itself does not include explicit interpretation.
However, the control strategy for FIVE operations are based on an implicit evaluation of intermediate results according to the Customer's needs (see Sections 5 and 9).
FIVE SOPs should include strategies for providing alternate hypotheses or results based on technical considerations; for instance when presenting the enhancement of a number plate and interpreting specific letters; see also Section 6.2 and [ENFSI S-FIVE BPM Supplement].

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.
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.
Expert-witnesses 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.

Every presentation of FIVE results as evidence has to fulfil the requirements of

- the Customer
- the relevant legal process and
- the relevant quality management system

The presentation of results should include information about the peer review steps undertaken and any possible work done by or collaboration with other examiners or experts; see also Section 5.1.

13.2 Written reports and digital results

FIVE results are provided in the first instance in digital form, including

- digital Image and Video data (original and FIVE results)
- a written report or statement of witness

If the original or resulting data needs special software to be displayed, a version of this software that is suited for standard computer systems should be provided.
Whenever possible, processed data should be provided in a commonly used File Format that is able to store the Images without quality losses that would compromise the enhancement steps carried out.

The format and content of FIVE reports should be based on well-known standard text formats such as Portable Document Format (PDF). Restrictions should be implemented to avoid extraction from or placing Images and Videos into (other) digital documents such as insertion via clipboard, simple conversion between different document formats, etc. Any possible impact of the use of specific formats should be properly evaluated (considering, e.g., the impact of PDF Compression settings, etc.).

FIVE laboratories should provide all source Images for the included resulting Images in their original format (or in a lossless recoded standard format if the original format is expected to be troublesome), as well as the produced results.

If important additional Images or Video data, not corresponding to the source Images/Video or FIVE results, are included in a report, these Images should also be provided as an additional set of files. These files should also be stored in their original “best quality” format (as used for creating the reporting document).

If needed, the main reporting document should clearly refer to any externally supplied additional files, which may be the only option to properly appreciate the optimal quality of the obtained results.

Digital results may be accompanied by at least one signed hard copy of the report and hard copies of some or all of the Images. In this case, the Image quality of the hard copies should meet the requirements of the intended use.
Reports containing Videos lose part of their content when being printed on paper, and coloured elements may not be reproduced accurately when being printed (e.g., due to differences in device colour gamuts, etc.).Therefore, SOPs about reports and hard copies should account for these issues.

13.3 Oral presentation

Oral presentation and play-back of digital evidence may also subsequently be required.

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.

If the results of FIVE examinations are shown in court, it is important to deliver optimum Image quality. If possible, and if no loss of important information that needs to be shown can be guaranteed, all resulting Images and Videos should be coded and formatted in a way compatible with the hardware and software equipment at hand. Display devices (in particular projectors) may offer only a reduced luminance or colour spectrum (gamut), which may thus neglect aspects of some importance in the Images. If such deficiencies are found (e.g., during a check prior to the oral proceedings) they have to be stated to all relevant parties and resolved by additional equipment or manual adjustments if possible. It is the responsibility of the presenting expert to check that the quality of the presentation of any reported results is sufficient compared with the purpose of the examination.

If presentation of First Copy Video data is needed it may be difficult to play this material in court (e.g., native formats of rarely found CCTV systems). In these cases it is acceptable to present lossless recoded versions of the First Copy Video footage instead.

14 HEALTH AND SAFETY

There is no need for FIVE specific health and safety considerations. The general health and safety rules for handling digital evidence, Images and Videos should be applied to solve problems like

- exposure to indecent or disturbing imagery
- exposure to flickering Videos (for epileptics)
- dealing with chemical, biological, radiological, nuclear (CBRN) or other types of contamination of materials

It should be noted that the laboratory QMS, and thus also any FIVE SOPs managed within it, may also be dependent on legal, environmental and statutory employment and working condition rules concerning these issues.

Guidance with respect to accommodation and environmental conditions is also discussed in Section 4.4.

15 REFERENCES

ILAC G19:08/2014
"Modules in a Forensic Science Process", download 04.09.2015 ilac.org/publications-and-resources/ilac-guidance-series/

ISO 9000:2005
"Quality management systems – Fundamentals and vocabulary", www.iso.org/store.html

ISO/IEC 17000:2004
"Conformity assessment – Vocabulary and general principles", www.iso.org/store.html

ISO/IEC 17020:2012
"Conformity assessment – Requirements for the operation of various types of bodies performing inspection", www.iso.org/store.html

ISO/IEC 17025:2018
"General requirements for the competence of testing and calibration laboratories", www.iso.org/store.html

ENFSI QCC-VAL-002
"Guidelines for the single laboratory Validation of Instrumental and Human Based Methods in Forensic Science", 10/11/2014

ENFSI MP2011 S-FIVE Project Homepage: www.s-five.eu
Contact the ENFSI Secretariat or the ENFSI Digital Imaging Work Group if this internet resource would become unavailable

ENFSI S-FIVE BPM Supplement
Available via the ENFSI MP2011 S-FIVE Project Homepage and the ENFSI Digital Imaging Work Group pages on the Europol Platform for Experts (EPE).

ENFSI FIT WG BPM
"Best Practice Manual for the Forensic Examination of Digital Technology" (ENFSI-BPM-FIT-01, November 2015)

ENFSI DIWG Homepage
Digital Imaging Working Group, at ENFSI Homepage: www.enfsi.eu

ENFSI QCC-PT-001
"Guidance on the Conduct of Proficiency Tests and Collaborative Exercises within ENFSI", 27/06/2014

UK Digital Imaging Procedure
V2.1 November 2007 ACPO / HOSDB Publication No. 58/07, download 04.09.2015 www.gov.uk/government/uploads/system/uploads/attachment_data/file/378451/DIP_2.1_16-Apr-08_v2.3__Web_2835.pdf

US SWGIT (Scientific Working Group on Imaging Technology, USA) Documents Scientific Working Group on Imaging Technology, www.swgit.org/documents/Current%20Documents

US SWGIT (Scientific Working Group on Imaging Technology, USA) Section 23
"Best Practices for the Analysis of Digital Video Recorders", Version 1.0 2012.06.11, download 04.09.2015, see [US SWGIT Documents]

US SWGIT (Scientific Working Group on Imaging Technology, USA) Section 24
"Best Practises for the Retrieval of Digital Video", Version 1.0 2013.09.27, download 04.09.2015, see [US SWGIT Documents]

16 AMENDMENTS AGAINST PREVIOUS VERSION

Not applicable (first version)

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