Scientific Working Group
Imaging Technology

Disclaimer:

As a condition to the use of this document and the information contained herein, the SWGIT requests notification by e-mail before or contemporaneously to the introduction of this document, or any portion thereof, as a marked exhibit offered for or moved into evidence in any judicial, administrative, legislative, or adjudicatory hearing or other proceeding (including discovery proceedings) in the United States or any foreign country. Such notification shall include: 1) the formal name of the proceeding, including docket number or similar identifier; 2) the name and location of the body conducting the hearing or proceeding; 3) the name, mailing address (if available) and contact information of the party offering or moving the document into evidence. Subsequent to the use of this document in a formal proceeding, it is requested that SWGIT be notified as to its use and the outcome of the proceeding. Notifications should be sent to: SWGIT@yahoogroups.com

Redistribution Policy:

SWGIT grants permission for redistribution and use of all publicly posted documents created by SWGIT, provided that the following conditions are met:

1. Redistributions of documents, or parts of documents, must retain the SWGIT cover page containing the disclaimer.

2. Neither the name of SWGIT, nor the names of its contributors, may be used to endorse or promote products derived from its documents.

Any reference or quote from a SWGIT document must include the version number (or create date) of the document and mention if the document is in a draft status.

SWGIT

Scientific Working Group
Imaging Technology

Section 16

Best Practices for Forensic Photographic Comparison

OBJECTIVE

The objective of this document is to provide personnel with guidance regarding practices appropriate when performing photographic comparison as part of image analysis.

SWGIT POSTION ON FORENSIC PHOTOGRAPHIC COMPARISON

Photographic comparison is an intrinsic component of many scientific and technical disciplines. Such disciplines and industries include astronomy, geology, geography, medical specialties such as radiology and pathology, intelligence and surveillance, manufacturing quality assurance, and insurance. Forensic photographic comparison is recognized as scientifically valid within the forensic science community. The first publicly prominent Forensic Photographic Comparison examinations took place as part of the Warren Commission investigation into the assassination of President Kennedy. Photographic comparisons in this investigation were used to help establish the rifle as being Oswald's as well as to establish that the "Backyard Photos" were taken with Oswald's camera.

INTRODUCTION

Photographic Comparison is an assessment of the correspondence between features in images and known objects or images for the purpose of rendering an expert opinion regarding identification or elimination (as opposed to a demonstrative exhibit). Photographic Comparison is a subtask of Image Analysis, and general best practices issues are discussed in SWGIT document "*Best Practices for Forensic Image Analysis*". This document addresses issues specific to Photographic Comparison.

SCOPE OF FORENSIC PHOTOGRAPHIC COMPARISON

Forensic Photographic Comparison examinations may be conducted on virtually any item, subject, or image. Practitioners of Forensic Photographic Comparisons in the field of Image Analysis should have expertise in image science, an understanding of the principles of individualization, and knowledge relevant to the specific subject under examination. Practitioners should be able to demonstrate sufficient knowledge of the subject matter to support their conclusions.

Several other forensic disciplines rely extensively upon photographic comparison techniques as a part of their procedures, such as footwear and tire impression analysis, latent print analysis, questioned document analysis, trace evidence analysis, and tool mark analysis. These subject matter experts use photographic comparison as a tool within the context of their domain expertise. This document is geared toward those comparison examinations typically performed by Image Analysis examiners outside the scope of these other disciplines.

This includes, but is not limited to:
  ➢ Facial and body comparisons;

This document includes a cover page with the SWGIT disclaimer

> ➢ Object comparisons, such as clothing, vehicles, weapons, luggage, structures;

> ➢ Comparisons of a questioned image with a known camera to determine if the image was captured using that camera.

VALIDITY

The basis for conclusions reached through photographic comparison lies in the detection of correspondence or discordance of subject features. In some cases, a statistical model may exist, or a model can be developed which will provide a formal, probabilistic basis for a conclusion. In other cases, statistical models may not be practical.

The absence of a statistical model does not necessarily preclude formulating a sound conclusion. In such cases, expert experience is critical for the recognition of features and their significance. These experts must be able to explicitly state the underlying assumptions, observations and chain of reasoning behind their conclusions in order to demonstrate that validity.

CRITICAL ASPECTS OF FORENSIC PHOTOGRAPHIC COMPARISON

There are a number of critical practices, processes, and factors used to ensure and demonstrate validity in forensic photographic comparison. The relative importance of any one of these may vary among cases. Regardless of the protocol used in conducting photographic comparisons, the methodology used should be documented.

Class vs. Individual Characteristics

The concept of class vs. individual characteristics is fundamental to forensic photographic comparison. Class characteristics are used to subdivide things into groups or classes. Individual characteristics allow one to differentiate objects within a class from one another. Individual characteristics may be used to uniquely characterize an object. They arise from such events as random natural processes, intentional alteration, and wear-and-tear.

The ability to identify an individual person or object requires a correspondence of individual characteristics. The number of such characteristics necessary for such an identification is a function of the subject matter, the quality and quantity of details in the images, and the expertise of the analyst; no arbitrary number of characteristics is required. A correspondence of class characteristics may be useful for establishing candidate subjects. Likewise, a discordance of class characteristics can be used to eliminate potential subjects.

ACE-V

A commonly accepted protocol applied to photographic comparisons is ACE-V (Analysis, Comparison, Evaluation – Verification). Not all photographic comparisons invoke this protocol. It is commonly invoked in footwear impression and fingerprint examinations, but it is uncommon in medical image evaluation and in photogeology. Some practitioners use a formalism referred to as "ACE-VR", which adds a "Report" phase. Other practitioners, such as physicians, do not use ACE-V but instead use conceptually similar approaches appropriate for their discipline.

The Analysis stage involves a thorough assessment of the properties and attributes of the features contained in the images under examination. While the features involved are

This document includes a cover page with the SWGIT disclaimer

objectively determined, the cognitive assessment of these features is an inherently subjective process. This includes determining which features are class or individual characteristics as well as issues of image formation, such as resolution, lighting, focus, and camera-to-subject geometry.

In the Comparison stage, an assessment is made of the correspondence/discordance of the characteristics identified in the Analysis stage.

In the Evaluation stage, a tentative conclusion is reached and the correspondences/discordances are tested against it. All discordances are evaluated to determine if they reflect true differences between the subjects.

Three types of discordance may be observed:
 (1) *Explainable differences*. Discordances may result from the imaging process or conditions in the scene.
 (2) *Unexplainable differences.* Discordances exist, but are of unknown source and significance.
 (3) *Exclusionary differences.* Discordances that reflect a true difference between the objects under comparison. Such a difference establishes an elimination.

If no exclusionary differences exist, the quantity and quality of corresponding features are used to determine the level of correspondence and the results are documented. As a result of this evaluation the final conclusion is formed. The discussion of statistical vs. cognitive evaluation below applies to this stage.

In the Verification stage, the results of the examination are evaluated through independent review by a comparably trained individual.

Recognition of Imaging Artifacts
In order to accurately interpret the content of an image under examination, it is imperative that the examiner not mistake artifacts of the imaging process as reflective of physical properties of the subject depicted. For example, a watermark on a passport photograph should not be misinterpreted as a tattoo on the subject depicted. Likewise, resolution, compression, optical defects, sensor defects, lighting conditions, atmospheric conditions, and motion, among others, may introduce barriers to correct interpretation. It is for this reason that SWGIT strongly recommends image science expertise, in addition to subject matter and individualization expertise, be applied to forensic photographic comparison.

Statistical vs. Cognitive Evaluation
In some cases, statistical models have been developed for photographic comparisons. When available, these models can be of great use. In other cases one may conceive of a statistical basis for individualization but one has not yet been developed. For others, development of a statistical basis may not be possible or may not be practical.

Cognitive Evaluation is the drawing of conclusions from visualized features. It involves testing hypotheses against known circumstances and observed features to find the best fitting hypothesis. Part of this is perceptual analysis, consisting of the comprehension and recognition of significant features by a trained eye and the cognitive ability to not only see, but recognize what one observes and relate those observations to circumstances. A trained

eye is not merely the recognition and memorization of lists of features, but represents a complex cognitive analytical process.

Another feature of cognitive evaluation is to place those observations within a method of inference. Very few real-life inferences involve statistical models. Many involve what is called "abductive inference," commonly described as "inference to the best explanation." In this method of inference numerous hypotheses are tested against known circumstances and that hypothesis which is most consistent with the circumstances and without contradiction by the circumstances is proposed as the most likely explanation. While early work by C.S. Peirce focused on the use of abduction in hypothesis formation, later work has focused on its use for confirmation. While abductive inference by definition is not to "certainty", it may asymptotically approach certainty in terms of confirmation.

Visual evaluation of an image by an individual with domain expertise often involves an intrinsically cognitive evaluation. Recognition of features in an image by subject matter experts may not have a statistical component. For instance, the identification of the make and model of a vehicle depicted in a surveillance image is not a statistical process. Likewise, comparison of antemortem and postmortem dental x-rays for the purposes of identification does not involve a statistical analysis but involves cognitive evaluation. In contrast, statistical models of clothing manufacture can provide a numerical probability of individualization.

Expertise and Experience
Before conducting forensic photographic examinations, individuals should have expertise in a number of areas. The most critical of these are image science, subject matter expertise, and the science of individualization.

Image science expertise is necessary to understand the creation and evaluation of artifacts of the imaging process. Subject matter expertise is necessary to understand the significance of features. Understanding individualization is necessary to assess the utility of the features for comparison leading to identification or elimination. This diversity may require both formal and practical cross-training among multiple disciplines or it may require the involvement of multiple individuals with a variety of expertise.

Expertise may be developed in response to the needs of a specific case. For instance, a comparison involving an item of clothing may require research into the manufacturing process.

Training, Competency, and Proficiency
Training should provide a basic level of competence. The translation of training into practice requires real-world experience under supervision by qualified personnel. The value of such experience must not be underestimated. A fundamental feature of image comparison is the cognitive ability to visually recognize important image features. This skill comes from experience. Training, competency, and proficiency for image analysis are discussed more fully in SWGIT document "*Best Practices for Forensic Image Analysis*"

Infrastructure for Forensic Photographic Comparison
Competent photographic comparison requires adequate technological and physical support,

This document includes a cover page with the SWGIT disclaimer

ranging from hardware and software to environments adequate for proper visualization.

A steady workload facilitates the development of experience. Agencies are encouraged to ensure that their image analysis experts are given a case load that is manageable, yet sufficient to maintain proficiency.

Managers should recognize that working a single case involves many factors beyond the processing of images for comparison and noting of similarities and dissimilarities. In addition to administrative and quality requirements, there may also be the need for additional research, testing, and consultation in order to achieve a conclusion. Failure to allocate sufficient time per case to the examiner may also eventually lead to error and incomplete examination.

BEST PRACTICES
Note: Although the paragraphs below refer primarily to the comparison of images, the principles also apply to the comparison of images and physical objects.

Bias
It is the duty of the examiner to conduct all examination tasks without being influenced by bias.

Selection of Images for Comparison
If the submitted images include more than one depiction of the questioned and known objects, then the practitioner should screen them to determine which images will be useful for analysis. Once selected, images are then processed as necessary.

Comparison Process
Photographic comparisons commonly involve an examination and evaluation of features observed in a submitted image compared to features of a known subject. This process may require image processing to enhance features for comparison.

Reconstruction
Often it is necessary to determine that issues of image creation, lighting, and composition do not create artifacts that affect the comparison. Reconstruction of the circumstances of the questioned image acquisition may be necessary.

This reconstruction may consist of photographing the object under comparable conditions as seen in the questioned image or otherwise duplicating them by real or virtual means.

Figure 1. This figure demonstrates differences in the appearance of an object when the camera has a different spectral response. (Left) Color photograph. (Center) Video still from black and white camera with IR blocked out. (Right) Video still from black and white camera with IR allowed to pass.

This document includes a cover page with the SWGIT disclaimer

Levels of Findings

In those cases where a statistical basis for decision making exists, the level of finding should reflect the appropriate probability. The underlying assumptions, particularly simplifying assumptions, for the statistical model should be reported.

In those cases without a statistical basis, a clear indication of the strength of the conclusion should be given; this will necessarily be a descriptive statement and not a numerical probability. Most agencies employ a scale of reporting with a certain identification at one end, certain elimination at the other, no conclusion in the middle, and some number of intermediate steps. In addition, there may be some indication of the suitability of the sample for comparison, particularly if it precludes a finding.

As illustration, three scales currently used by agencies are given below:

Continuum of Conclusions Examples For Photographic Comparative Analysis			
Identification **No conclusion** **Elimination**	Identification	Identification	Identification
	Similar		Powerful support same
		Similarities noted	Strong support same
			Moderate support same
	No conclusion, but with similarities	Neither/Nor – with explanation	Limited support same
			Inconclusive
	No conclusion		Limited support different
	No conclusion, but with dissimilarities		Moderate support different
			Strong support different
	Dissimilar		Powerful support different
	Elimination	Elimination	Elimination
	No comparison Possible	Not suitable – with explanation	No comparison Possible

It should be noted that the criteria for a full identification are a function of image quality and the clarity, relative weight (often subjective) and number of individual characteristics. No arbitrary number of individual characteristics is necessary to effect an identification.

Photogrammetry and Forensic Photographic Comparison

Images subject to photographic comparison may not include a scale or other means of directly defining the size of the questioned object. In many of these cases the issue of comparison does not depend upon the scale. In such cases a conclusion can be made in the absence of an explicit determination of the size. For example, the determination of the make and model of a car does not require a determination of the exact wheelbase. In other cases, the relative or approximate size is sufficient. For example, a corresponding number of buttons on a shirt when compared to shirts of the same design could be used to demonstrate a similarity in size, but cannot provide a quantitative estimation.

In other cases, it may be necessary to demonstrate a comparable size through either direct or indirect measurement. This can be accomplished by photogrammetry. See SWGIT document "*Best Practices for Forensic Image Analysis*".

Care must be taken in deriving 3-dimensional measurements from 2-dimensional imagery. Differences in imaging conditions can lead to differences in measurements despite the fact that the identical feature is being measured in both images. Likewise, the subject of examination could change over time. For instance, a person could gain weight. These differences are explainable, but must be recognized and accounted for.

Photographic Documentation as a part of Comparison/Analysis

In some cases it may be necessary to photograph a partial reconstruction or model to demonstrate corresponding features or differences between the questioned and known objects. Some factors to take into consideration are: lighting, camera to subject geometry, spectral sensitivity of the camera sensor or film, optical properties of the questioned object and other objects in the scene, deformation of the subject (e.g. folds in clothing), viewing conditions (including effects of weather), and optical distortions in the lens and camera enclosure. **See Figure 1** for an example in which spectral sensitivity was documented.

EVIDENCE MANAGEMENT

Items subject to photographic comparison may also be analyzed by other forensic science disciplines. Laboratory management should be aware of the possibility of photographic examinations and its placement in the overall analytic work flow. The sequence of examination is critical for photographic comparison examinations because other examinations may render the object unsuitable for comparison. For example, removal of fabric from clothing for DNA analysis can destroy visually significant features. Identification marks placed on shoes during footwear impression examinations can also adversely affect the comparison.

Similarly, the improper handling of an object during photographic comparison may contaminate or alter it, and adversely affect the outcome of subsequent examinations. For example, latent fingerprints may be destroyed.

QUALITY CONTROL/QUALITY ASSURANCE

A photographic comparison laboratory is not a drug chemistry laboratory with the same methodologies and instrumentation. Therefore, the concepts of drug chemistry standards and controls do not always directly apply. While criteria should be developed to assure appropriate processing and evaluation of images, arbitrary quality control methodologies may not have a meaningful direct application and may not be appropriate. For instance, requiring a daily log indicating if a microscope light turns on does not serve a particularly useful calibration purpose in standard histologic evaluation. If an examiner sits down at his or her microscope and notices the light does not turn on, he or she can simply change the bulb. In contrast, there may be instruments, such as densitometers or displays used for colorimetric evaluation, where traditional calibration is appropriate.

This document includes a cover page with the SWGIT disclaimer