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**Review 1998 – 2001 from the Coordinating Laboratory on:
QUESTIONED DOCUMENTS
(other than Handwriting)**

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INTRODUCTION

This review covers advances in the field of Forensic Document Examination (other than Handwriting) reported since the 12th INTERPOL Forensic Science Symposium in 1998. Advances in forensic handwriting examination are reported separately (see Questioned Documents – Handwriting).

The review is based on:

1. Articles published in the major forensic science journals as well as papers presented at international forensic QD meetings during the period 1998 to 2001.
2. Results of a survey among INTERPOL Member forensic science services and leading forensic document laboratories, requesting relevant contributions as well as complementary information on the quality assurance policies within the reporting service.

The following INTERPOL Member States provided information for this review:

Argentina, Australia (various services), Bosnia-Herzegovina, Botswana, Bulgaria, Denmark, Croatia, Cyprus, Canada, France, Finland, Germany, Greece, Italy (various services), Israel, Japan, Latvia, Lebanon, Malaysia, Netherlands, New Zealand, Norway, Slovakia, Slovenia, Singapore, South Africa, Spain (various services), Sweden, Switzerland, Turkey (various services), United Kingdom (various services), USA (various services).

Reported advances in the field of Questioned Documents were considered in both 2001 QD Reviews, i.e., handwriting / non handwriting evidence.

REFERENCES

The listed references indicate that among the major international forensic science journals, few are regularly publishing articles and technical notes on QD concerns. To be mentioned:

- 4# *International Journal of Questioned Document Examiners*, started in 1995, being at that time the leading journal for the international forensic QD community, however for different reasons was discontinued in 1998.
- 4# *Journal of the American Society of Questioned Document Examiners*, started in 1998, is currently the only international QD journal (in English), covering the wide-range of QD interests.

Few QD articles are published in the *Journal of Forensic Sciences* or *Science & Justice* (USA). Regarding other languages, the most relevant journal is *Mannheimer Hefte für Schriftvergleichung* (in German), and is dedicated to all aspects of QD Examination (including Handwriting).

Besides these journals, contributions to QD Examination including handwriting are mainly reported at major international QD meetings, such as:

- 4# The Annual ASQDE Meeting (American Society of Questioned Document Examiners)
- 4# The Biennial GFS Conference (Gesellschaft für Forensische Schriftuntersuchung)

ADVANCES IN QUESTIONED DOCUMENT EXAMINATION

(other than Handwriting)

The following is a summary of reviewed references with an overview of relevant contributions. For more information refer to the alphabetized list of references.

In general, the review indicates that there are no major ongoing national or international projects in the field of technical document examination. Published articles refer to individual research and development studies, and fall within one of the following categories:

- 4# Improvement of existing state-of-the-art methods
- 4# Ink analysis
- 4# Classification of documents produced by business machines (facsimile, photocopies)
- 4# Determination of writing sequence
- 4# Security documents / document security
- 4# Miscellaneous

IMPROVEMENT IN STATE-OF-THE-ART SCREENING METHODS

Electrostatic detection of indented writing by so-called ESDA methods – although considered for many years as the basic screening method for all types of Questioned Documents – still raises new questions and answers. If the ESDA method is of particular interest for the forensic handwriting examiner, it is nevertheless the Standard Operating Procedure (SOP) for all document examination approaches. Reported issues concern:

- 4# Survey of existing techniques
- 4# Use of ESDA to visualize typewriter and non impact printer indented markings
- 4# The cascading beads developer effect

- 4# Differentiation between primary and secondary markings
- 4# Evaluation of statistics
- 4# Digitally enhanced ESDA impressions
- 4# Optimal development conditions
- 4# Application of ESDA in sequencing writing impressions

Effective SOP examination in the extra-visual range (UV/IR) looks at frequently used tools such as Docubox (Projectina) or the VSC2000 (Foster & Freeman), where the latter now offers colorimetric (chromaticity) capabilities to quantify results (Anderson (4)).

The physical phenomena behind the most useful Electrostatic Detection Apparatus (ESDA) are based on new theories; *Seward (117)* brings forward new explanations, which do not agree with ESDA manufacturers. *Sperry & Tolliver (121)* discuss four methods to improve ESDA development impressions using digital enhancement techniques. The Seward-model is discussed with comments by *Tanaka (126)*.

INK ANALYSIS

The most widely reported field is Forensic Ink Analysis, which applies new instrumentation methods and techniques. The focus is the identification and particularly, the differentiation of writing inks and their age for ink-dating purposes.

Analytical issues concern:

- 4# Establishing a standard for Thin Layer Chromatography (TLC)
- 4# Using RAMAN and RAMAN-SERRS Spectroscopy for In-Situ analysis
- 4# Metal traces in inks
- 4# Effectiveness of High Pressure Liquid Chromatography Ink Analysis compared to optical methods
- 4# Ink identification by (diode array) spectrophotometry
- 4# SEM-EDX analysis for the examination of pencil marks
- 4# Comparison of optical and chemical methods in the examination of ballpoint pen inks
- 4# Analysis of ballpoint pen inks by instrument analysis, such as:
 - § High Pressure Liquid Chromatography
 - § High Performance Capillary Electrophoresis
 - § Field Desorption Mass Spectrometry
 - § Capillary Electrophoresis coupled with Laser induced fluorescence
 - § Fourier Transform IR Spectrometry (FTIR)
 - § Micro ATR technology
 - § Solid Phase Micro Extraction (SPME)

The discussion on basic ink characteristics include:

4# The oxidation of ferrous iron in iron gallon ink

Reliability of the solvent extraction technique as an indicator of age shows (ongoing) conflicting results (*Aginsky (2)*, *Andermann & Neri (3)*). *Brazeau et al (12)* propose the use of Solid Phase Micro Extraction (SPME) by analysing the volatile components chromatographically as a new and effective and almost non-destructive method to determine the aging characteristics of ink. *Cheng et al (24)* established an experimental condition that could identify the subtlety of forged ballpoint pen ink strokes effectively without factoring conditions such as paper and pen type, writing pressure or other conditions of the sample. *Claybourn & Ansell (27)* as well as *Jaufman (61)* demonstrate the use of RAMAN Spectroscopy as a powerful tool to distinguish black ballpoint pen inks. The studies from *Khanmy-Vital et al (64)* as well as *Sakayanagi et al (113)* indicate that it is possible to distinguish between manufacturers of ballpoint pen inks by Field Desorption Mass Spectrometry. *Li (73)* shows that microspectrophotometry might be useful to show alterations in ballpoint pen inks, since different degrees of oxidation will result in different spectra. *Lyter (82)* compared the discriminating power of IR-Reflectance, IR-Luminescence, RAMAN Spectroscopy as well as TLC when applied to black ballpoint pen inks and found that RAMAN was giving the best results. The research by *Mazzella (88)* on diode array micro spectrophotometry of ink-jet printers resulted in the differentiation of 60 printers of various types. *Wang et al (135)* concluded that the extraction technique approach on dating ballpoint pen inks, allows differentiation between natural and artificial aging. Amicro-ATR technology for the examination of blue ballpoint pen ink, as presented by *Wang et al (137)* has proven to be fast, highly sensitive and non-destructive. *Whiting (140)* shows that the advantages of HPCE over HPLC for discrimination of ballpoint pen inks include lower operating costs and the use of buffers rather than solvents.

DOCUMENTS PRODUCED BY BUSINESS MACHINES

It goes without saying that the proliferating market of modern business technology such as copiers, fax machines and printers reduces a systematic forensic approach. However, a number of projects report progress in the following:

- 4# Image retrieval from used thermal transfer printer rolls
- 4# Defining substrate attributes for photo quality ink-jet imaging
- 4# Detection of laser printer defects for printer identification
- 4# Evidential value from ink-jet printers and inks
- 4# Identifying photocopying toners using FTIR, DRIFTS and Pyrolysis-GCMS
- 4# Classification of ink-jet printers and ink
- 4# Classification of and identification of Laser printers
- 4# Electronic database of computer printer data
- 4# Examination of faxed documents
- 4# Classification and identification of fax fonts

- 4# Classification of full colour copiers
- 4# Counterfeit Protection System codes of laser copiers
- 4# Dot patterns of colour ink-jet printers

Doherty (31) gives an overview on state-of-the-art classification of ink-jet printers and inks. Interestingly, the findings indicate that the results of TLC analysis “before” and “after” show significant differences because the ink-components are modified by heat during the print process. For specialists in traditional typewriting examination, the overview of *Frensel* (41) on typewriters produced in the former East Germany is of interest when identifying products manufactured before and after World War II. *Gervais & Lindblom* (43) present a case illustrating detection of digital manipulation on a facsimile printout. *Hammond* (47) compares the collected technical data of facsimile machines. The demonstration of secondary typewriting and alterations by the use of grids is today easily carried out by using the appropriate computer software, as shown by *Hicks* (55). If there are actually different computer assisted typewriting data collections, the system DRUIDE, developed by *Holzappel & Marx* (58) is comprehensive and designed for routine casework. The traditional typewriter – disappearing on the market – still has its forensic impact. Few references go back to the roots of typewriting examination and commercial production, e.g., in the former Eastern Block. *Horton* (60) compares the identifiability of the flatbed scanner and its products by comparing the marks on scanned images. *Lauterbach* (68) describes 30 fax machines and their characteristic printouts for identification purposes. A survey by *Tweedy* (129) on state-of-the-art colour Laser copier identification by bitmap coding includes an overview of counterfeit protection by the characteristics and class of the major copying machines on the market. *Wagner* (134) presents the “Australian Toner Library” and the discriminating power of FTIR as compared to ATR. In a similar direction, but looking more specifically at the dating and sourcing of the Transmitting Terminal Identifier on a fax document, is a study by *Westwood & Novotny* (138). *White et al* (139) show the benefits of Surface Enhanced Resonance RAMAN Scattering Spectroscopy (SERRS) for an almost non-destructive spectroscopic examination of inks. *Winter* (141) studied the evidential value of the dot pattern of colour ink-jet and bubble-jet printers for individual identification.

DETERMINATION OF WRITING SEQUENCE

Relative age determination by establishing the writing sequence is an ongoing challenge. New alternatives to complete the range of traditional approaches include:

- 4# Scanning Electron Microscopy
- 4# Use of “alternative microscopes”: Laser Scanning Confocal Microscope, 3D Spatial Microscope
- 4# Use of Atomic Force Microscopy
- 4# Colorimetric CIE Lab colour system duplication
- 4# In-Situ molecular analysis by TOF-SIMS

Anthony (6) reports on software, which allows 3D viewing of digitised signatures – an approach to be considered for line sequence determination. *Lyter & Linto* (83) consider the examination of line crossing by TOF-SIMS (Time-of-Flight Ion Mass Spectrometry), to be an accurate method for the determination of writing sequences, which according to the nature of crossing lines, is the ultimate alternative to scanning electron microscopy examination. *Strach et al* (124) evaluated statistically the results of line crossing examinations by ESDA, as a basis for Bayes' theorem considerations.

SECURITY DOCUMENTS

The contribution to security document concerns, as reported in forensic journals and during forensic document meetings, does not reflect this major casework issue. On the one hand, this is due to the fact that ID document checking is a major domain of the immigration and naturalisation services that operate their own forgery desk laboratories. On the other hand, the frightening worldwide increase in counterfeiting security documents such as passports, ID cards or payment cards, does explain why the prevention and detection of security document forgery has become a high priority target outside the traditional forensic approach. INTERPOL has its own forums to discuss technical advances in this field (see www.interpol.int). Besides banknotes and passports, payment cards too have become complex technical systems with many optical and electronic features to prevent forgery. Nevertheless, organised crime uses this method of counterfeiting on a massive scale. *Cheng et al* (23) discuss the growing trend of forging security documents with personal computers. *Friedrich* (42) gives an overview on state-of-the-art security document technology. INTERPOL has set up an on-line counterfeit payment card database to combat the situation (*Lakeman* (67)). *Leung et al* (72) approach the identification of credit card encoders by hierarchical cluster analysis of the jitters of magnetic strips.

Similarly, efforts are underway to develop a database for payment card embossing machines (*Michaud et al* (92)). *Varsney & Mehrotra* (130) explore a non-destructive use of a TLC scanner for the characterisation of colours in currency notes on similar material.

MISCELLANEOUS

A study of two paper cutting machines and processes at a large paper company was made by *Bodziak* (9) to determine if more than one pad of paper can result in identical edge features on each of the four sides. The process each machine uses to cut paper stock, the edge characteristics that result from the guillotine blade and the likelihood of duplicate features, are discussed. New commercial products from Brother allow easy creation of computer assisted flat die stamps by using thermo transfer printing technology; tests reported by *Kelly* (65) show that stamp images produced by this new technology can be identified and respectively, differentiated from "traditional" flat die stamps. *Licht & Brown* (76) describe a new chemical reagent to substitute Xylene with similar effectiveness, but less hazardous to health. *Vos et al* (133) tested the effect of sunlight and fluorescent light tubes on inks and papers.

QUALITY ASSURANCE

Even if there is a common agreement on the necessity and added value of quality management to guarantee quality assurance within a forensic science service, the Forensic Document Examination discipline is only one of the difficult areas that need to establish and maintain a policy on quality.

Quality management measures taken within reporting QD services fall into three distinct categories:

1. Few QD laboratories belong to a quality-accredited service. Most work primarily with institutionalised QA activities and regulations.
2. A majority of QD laboratories regularly participate in proficiency testing such as those commercially available by the Collaborative Testing Service (CTS). In addition, the European QD laboratories report participation in the proficiency tests offered by the Working Group of Questioned Document Examiners within ENFSI (European Network of Forensic Science Institutes). These ENFSI proficiency tests are monitored by a steering committee and cover all aspects of technical document examination.
3. A minority of QD laboratories – especially laboratories not participating in a forensic science Institute network – where no organisational QA measures are taken.

TRENDS AND PROSPECTS

Considering the reported advances, there is hope that the proliferating market of modern business machine technology still has a potential for scientific forensic investigation. The field of application however, is no longer local but universal. Major contributions therefore, should focus on international surveys and data collection representative to the QD community. A leading service and particularly, a group of cheerleaders in QD examination should coordinate such projects.

Efforts made to create improved proficiency testes, which provide more valuable information on forensic effectiveness are promising. They show the real need to leave QA not only to commercials, but also to the QD community itself, who knows best which weak points have to be addressed.

There are presently initiatives to define on a regional and respectively, international level “best practice manuals” for standard QD examination methods and techniques. Hopefully, the results will be beneficial for large user groups.

Missing today and challenging tomorrow are coordinated efforts in the field of training QD experts. Internationally attended training courses in this complex area are still missing. At the coordinating laboratory for QD examination, a number of requests for training have been received from developing countries. The overview on laboratories offering training support in the field of QD examination does not exist. If it is true that QD areas such as instrumental analysis are interdisciplinary and therefore focusing on a broader forensic application than just QD, there are nevertheless forensic QD areas, which are highly specialised and not practised outside the forensic field, e.g., determination of writing sequence or the examination of documents produced by business machines. It would be helpful for the less specialised forensic services to know where to get scientific support to train its own specialists.

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