Establishment of an operational system for drug profiling: a Swiss experience

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ABSTRACT

The present article describes the profiling process developed at the Institute of Forensic Science of the School of Crime Sciences of the Faculty of Law at the University of Lausanne. The technique is oriented towards an operational approach that can be applied directly by drug units of local law enforcement authorities.

The background of the development of that technique and issues relating to data sources are outlined. Analytical, statistical and computerized methods for detecting, managing and visualizing linkages are examined in the context of drug profiling. Harmonization of methods and operational use of links are discussed and explained using examples. Finally, adequate communication of forensic information/intelligence is explored as an area of development.

This endeavour has helped demonstrate the enormous potential that linking seizures made in different regional markets has for police investigations.

The next stage is to focus on implementing this model in a more systematic manner and, if possible, at the national level and even the international level. That harmonization of methods should be pursued in order to maximize the potential of the detected linkages.

In conclusion, links established through profiling, combined with traditional information, can be utilized to better understand the market's structure and implement medium- and long-term investigation strategies.

Keywords: drug profiling; forensic intelligence; harmonization; contextualization; intelligence-led approach; police data integration

Background

There are many possible strategies to combat drug trafficking, focusing on preventive or enforcement action against trafficking networks at every stage in the process, from drug production to drug distribution and consumption in local markets. For law enforcement authorities, that means selecting the most effective operational methods and strategies given available resources. An

intelligence-led approach bases action choices on sound knowledge of the criminal mechanisms involved, obtained through the structured and systematic processing of available data.

That approach requires the design and implementation of information processing methods to provide intelligence. The first stage involves gathering and organizing relevant data from human and electronic sources. Once that information has been collated in databases, it is interpreted to produce useful hypotheses and formulate recommendations that aid decision-making [1].

The considerable quantities of drugs seized from traffickers yield data collections that can form a useful basis for such procedures. However, one key preliminary issue remains largely unresolved: what intelligence can be derived from those illicit substances?

Swiss profiling experiences seek to answer that question by systematically recording the physical and chemical characteristics of various seized drugs. The resulting data sets are interpreted to produce useful intelligence on drug trafficking from both the operational and the strategic perspectives.

Typical legal procedures require the analysis of qualitative and quantitative aspects of the banned substances. Such analysis is generally interpreted as the evidence on which the justice system bases itself in formulating its decisions according to the laws in force. An intelligence-led approach is more ambitious and expands the possible ways of exploiting data sets on seized drugs.

Process description

A general representation of an intelligence process based on drug seizures is shown in figure I. Several organizations cooperate in carrying out the process according to a division of tasks integrating each participant's responsibilities. For example, police officers and border guards seize drugs, transfer them to sometimes distant laboratories, which analyse the samples and interpret the results. All those operations take place within a legal and economic context that can be very limiting and which often varies from jurisdiction to jurisdiction.

Figure I. Integration of intelligence
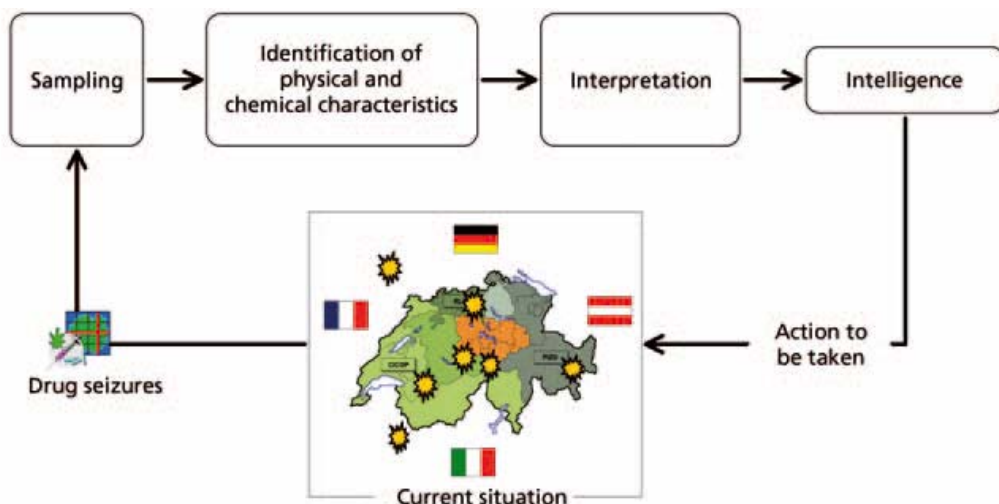
To be useful, intelligence has to be transmitted in real time, that is, within a time period appropriate to the pace of developments of the crime phenomena being dealt with. Strategic analysis, which is used to evaluate the extent, patterns and impact of trafficking, accommodates delays in information availability more easily than does operational analysis, where intelligence can be used to guide an investigation in progress. Thus, in dispatching seized drugs to laboratories for identification of physical and chemical characteristics, speed is crucial. Once the drugs are in the possession of the laboratory or laboratories, physical and chemical analyses can be carried out to isolate the characteristics of the seized substances. However, the entire seizure cannot be systematically analysed, since such an operation would be far too costly and time-consuming. Thus, only small quantities (samples) are selected for analysis. The measured quantities (the profile) will then be assumed to be representative of the characteristics of the entire seizure. That operation, called "sampling", follows strategies based on statistical considerations.

It would not be feasible to centralize all processing activities in a single laboratory with the aim of creating an international databank. Thus, it is necessary to ensure that all entities involved use the same methods in the same manner, with similar facilities so that the results obtained will be comparable. The quest for harmonization does not stop there, given the many parameters to be taken into account and the sensitivity of the methods applied.

The data are then arranged in a memory, usually in an electronic format. Seizures are not stored individually but are collated and grouped in classes according to similarities of the profiles identified. How are the classes defined and interpreted? The links between seizures can be of different types and of different degrees: do those links mean that the drugs are from the same batch, are distributed through the same networks or come from the same region?

The question of the representativity of collected data warrants particular attention. Are such data more indicative of police activity or of the real characteristics of drug trafficking? A clear description of the conditions in which seizures were made can provide details to be incorporated into interpretative analysis.

Once the memory is established, it can be used to generate intelligence. For that purpose, computerized techniques for recognizing patterns in large quantities of data can be applied. Such patterns should draw attention to specific data sets of special interest. For example, a compound may appear in an unusual quantity during a particular period. Those patterns, which may be concealed by the large quantity of recorded data, can provide valuable intelligence on trafficking trends. The potential offered by such techniques is now being systematically studied.*

The potential of compiling information in such databases is still not entirely appreciated. Combining intelligence with information from police investigations and strategic analyses gives an indication of the possible applications of those data sets.

Data sources: the Swiss context

Switzerland is divided into 26 cantons, each with a law enforcement authority that is largely independent in the field of drug control. In addition, two municipal police authorities (Zurich and Lausanne), with extensive legal authority, conduct investigations in their jurisdiction. The Federal Criminal Police, which in theory has sole responsibility for drug trafficking as part of organized crime, constitutes a further entity within this highly fragmented system.

Since 1998, the Institute of Forensic Science (IPS) of the School of Crime Sciences of the Faculty of Law at the University of Lausanne, through its specialist drug analysis team, has been raising police awareness of the advantages of physical and chemical profiling. Operational intelligence for investigators and strategic intelligence for decision makers are provided, in addition to qualitative and quantitative data required by judicial officers to determine the crimes committed. Police quickly realized the value to investigations offered by this new form of intelligence.

Drugs seized in the cantons of Geneva, Vaud, Neuchâtel, Jura and Tessin by the Federal Criminal Police and the Lausanne city police are analysed in the IPS laboratories. An initiative carried out in coordination with the Scientific Forensic Service of the Zurich City Police resulted in a representative analysis of seizures of amphetamines and derivatives over a large area (see figure II).

The data thus relate to western and southern Switzerland, as well as to the Zurich area for amphetamine-type stimulants and derivatives. The lack of a centralized structure or network of laboratories using harmonized methods is regrettable. The lack of coordination partially conceals linkages, making a nation-wide picture impossible—a problem known as linkage blindness. However, the data are sufficiently representative that they can be used in an operational system for the systematic analysis of seized drugs in order to provide law enforcement officials with concrete operational intelligence within a limited area. Based on acquired experience a more ambitious process, covering a wider area can be envisaged.

Each year, 1,600 analyses are carried out for some 260 cases on average. The drugs most analysed are heroin, followed by cocaine, amphetamine derivatives and cannabis. Various other drugs, such as amphetamine, khat, psilocybine and lysergic acid diethylamide (LSD) are seized only occasionally in the areas concerned.
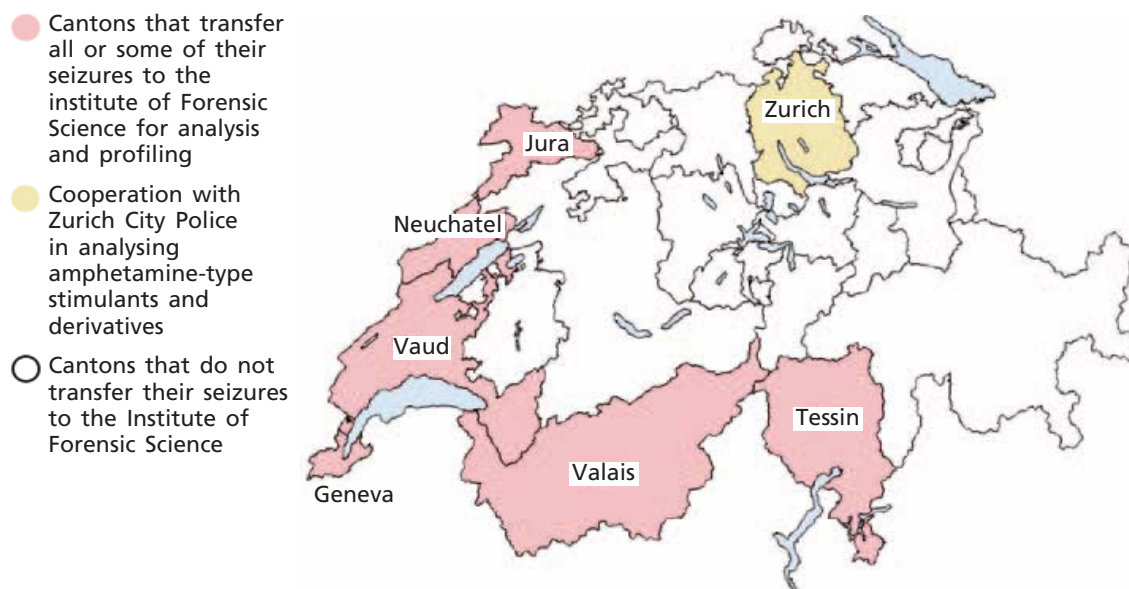
Submission of seizures

The standard procedure for the submission of seizures (see figure III) generally begins with the forensic department (investigating technical officers) of the

canton concerned. The department photographs the containers, collects relevant trace evidence such as DNA and fingerprints, notes the gross and net weights of the seizure and takes samples using an ad hoc protocol.
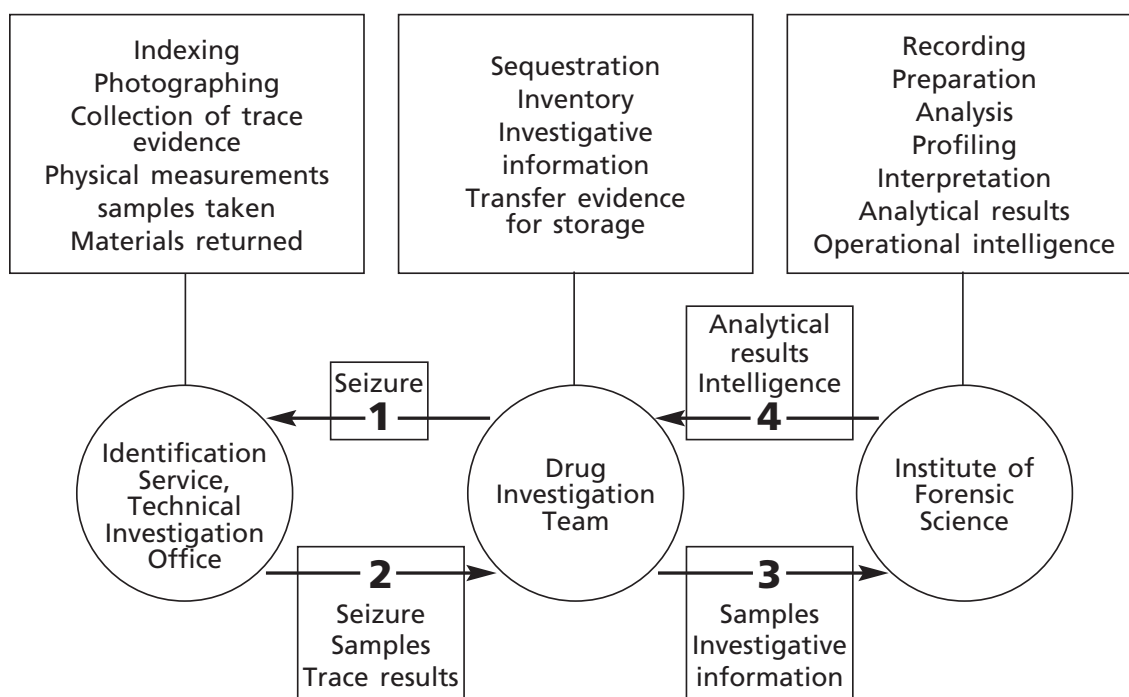
The samples and their transfer record are then forwarded by the inspectors in charge of the case. This procedure makes it possible to obtain investigative information, such as dates and place of seizure, which are stored in the memory and subsequently incorporated into the process of interpretation.

Figure II.   Cantons submitting seized drugs to the Institute of Forensic Science

● Cantons that transfer all or some of their seizures to the institute of Forensic Science for analysis and profiling

● Cooperation with Zurich City Police in analysing amphetamine-type stimulants and derivatives

○ Cantons that do not transfer their seizures to the Institute of Forensic Science

Note: The boundaries shown do not imply official endorsement or acceptance by the United Nations.

Figure III.   Standard procedure for the submission of samples

Indexing
Photographing
Collection of trace evidence
Physical measurements samples taken
Materials returned

Sequestration
Inventory
Investigative information
Transfer evidence for storage

Recording
Preparation
Analysis
Profiling
Interpretation
Analytical results
Operational intelligence

Seizure
1

Analytical results
Intelligence
4

Identification Service, Technical Investigation Office

Drug Investigation Team

Institute of Forensic Science

2
Seizure
Samples
Trace results

3
Samples
Investigative information

Handling and analysis of seizures by the laboratory

Sampling

Crime investigation officers and forensic scientists are often faced with very large quantities of seized drugs. Only a limited quantity—ideally, the most representative sample of the seizure—is selected for analysis. However, if the sampling does not reflect variations that exist in the seizure, it is highly unlikely that the information on the composition of the seizure will be representative. Thus, the role of sampling should in no way be underestimated.

Under Swiss law and in the procedure described, sampling and the ensuing analysis must meet two requirements. First, from a legal viewpoint, the drug has to be identified and quantified, because those two parameters are important for determining the gravity of the offence committed, pursuant to Swiss federal law on narcotic drugs and psychotropic substances.

Secondly, from an intelligence viewpoint, it is important to examine the homogeneity of the seizure with respect to its constituent chemical and physical profiles. Mathematical tools available for this purpose can be divided into two main categories. The so-called frequentist approach gives an estimate of the quantity of drug based solely on the result of the analysis. The Bayesian approach is more comprehensive. It incorporates a set of information on the samples, including a priori homogeneity and the results of analyses, that makes it possible to assess the probability that the remainder of the seizure will contain a certain proportion of drug [2].

Economic factors can play an important role in the sampling process, because analyses are not free. A compromise has to be found between the information required and the expenses incurred in acquiring that information in collaboration with judicial and investigating officers.

The importance of the sampling stage will be discussed below, taking into account that in practice, choices are often made on the basis of the specific situation faced.

Two examples, which have been simplified and rendered anonymous, illustrate how sampling during the investigation affects laboratory analysis.

In case A, 12 kilograms of heroin were seized at the Swiss border. An investigator of the Federal Criminal Police suspected that the person arrested at the time of the seizure belonged to a particular criminal network. The investigator wished to compare the chemical profile of the 12 kilograms of heroin with the profiles of other seizures previously forwarded by him to IPS for analysis. In this case, a member of the laboratory went to the site of the seizure to collect a small sample quantity, the canton authorities being required to safeguard the evidence. The seizure consisted of 24 blocks of about 500 grams each. The optimum method would have been to drill into the blocks at several places chosen at random (core sampling). However, in view of the number of blocks and the restrictive conditions for taking samples—time was limited and the operation was carried out in a basement—it was decided to break each block in two and remove a piece across the entire width of the block. All pieces were homogenized by crushing and then analysed.

In another case a seizure of approximately 600 tablets took place. In this case, the criminal identification department of the canton carried out the sampling itself and forwarded 60 tablets, that is, about 10 per cent of the total quantity. From that first sample, only 10 tablets were selected for analysis owing to cost considerations. In such cases, if the physical and chemical characteristics of the 10 samples proves similar, the analysis ends there. If, however, several profiles are identified, the opportunity remains of increasing the number of samples analysed. That permits a greater representativity of the composition of the heterogeneous seizures.

The above-mentioned examples show that constraints influence the sampling process and that choices are made on a case-by-case basis. The analysis laboratory has little or no direct control over such law enforcement, practical, time and cost constraints. However, contact and communication between the laboratory and the relevant authorities can raise awareness among those who collect samples.

Determining variables for profiling purposes: criteria for selecting a method

Definition of a variable

Drugs contain not only their illicit compound, such as cocaine or 3,4 methylenedioxymethamphetamine. When a sample is analysed, it is possible to detect several other types of compounds, referred to as variables, which are mixed with the illicit drug in the course of its history, from production to seizure. Such compounds come from the living plant, synthesis (such as precursors and solvents) and the addition of cutting agents. In addition to those chemical variables, there are the physical variables, such as logos and the physical appearance of samples and their packaging.

The profile of a sample consists of the ensemble of those variables. Thus, there are several profile types (chemical, physical or mixed), resulting in the complexity, as well as the potential, of intelligence derived from drug seizures.
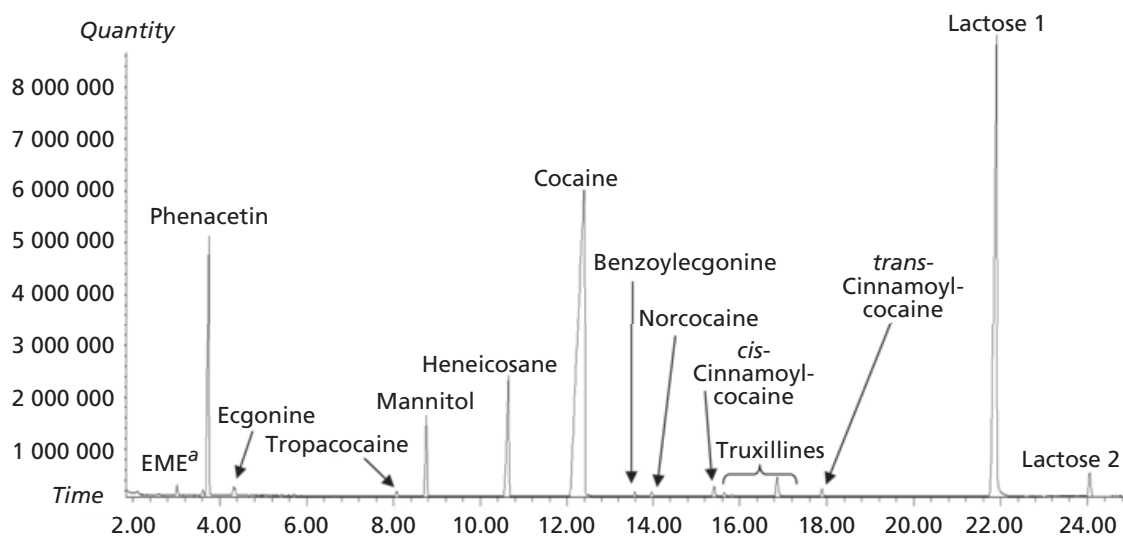
Selection criteria

Development efforts to date have focused primarily on chemical variables, which are presumed to have good intelligence potential. Also, the traditional function of commissioned laboratories has been to determine the active ingredient content. That is one of the chemical variables to be obtained from samples of heroin (diacetylmorphine) and cocaine (methylbenzoylecgonine). As a result, the analysis of such variables is an integral part of established expertise.

Laboratories have several analytical methods at their disposal to identify those variables. The aim, obviously, is to find the analytical method that produces the desired information as simply, as quickly and as economically as possible.

Gas chromatography has the advantage of producing maximum information from a single analysis, whereas other methods require a series of laborious and more costly operations and yield little relevant additional information. The analytical result of gas chromatography takes the form of a chromatogram, such as that in figure IV.

Figure IV.   Typical chromatogram of a cocaine sample

[a]Ecgonine methylester.

Selection of variables

The selection of useful variables is based on several criteria:

- The identified variables must be present in each sample.
- Their concentration must be sufficient to allow chromatography and differentiation from background noise.
- Their measurement must be reproducible and repeatable.
- They must be sufficiently numerous and of variable quantities in order to group samples possessing similar characteristics, while differentiating uncorrelated samples.

The relative quantity of variables is measured for each sample. In this case, as seen in figure V, the structure of the data can be represented as a matrix whose columns represent the peak area values of the selected variables and whose rows represent the different samples in the database. That matrix of numbers will be used for the mathematical operations described below.

Quality of results

Controlling the quality of results obtained is essential to be able to have comparable results in a single laboratory and among various laboratories. It is

essential to ensure that results are reproducible. A result obtained for a sample must be the same as one obtained one or two months later. The testing procedure also monitors the analytical quality of equipment used for analysis, as well as the comparison methodology used, including analyses of controls, test samples and standard solutions. Any defect potentially causing discrepancies in the profiling process is thus detected, bringing an immediate response from the analyst. That procedure ensures the reproducibility of the results entered in the memory of the system. The same monitoring procedures must also be implemented at all laboratories involved in order to harmonize their results.

Figure V. Extraction of data on profiling variables

n = Variables
m = Samples
x = Numerical values of peak areas
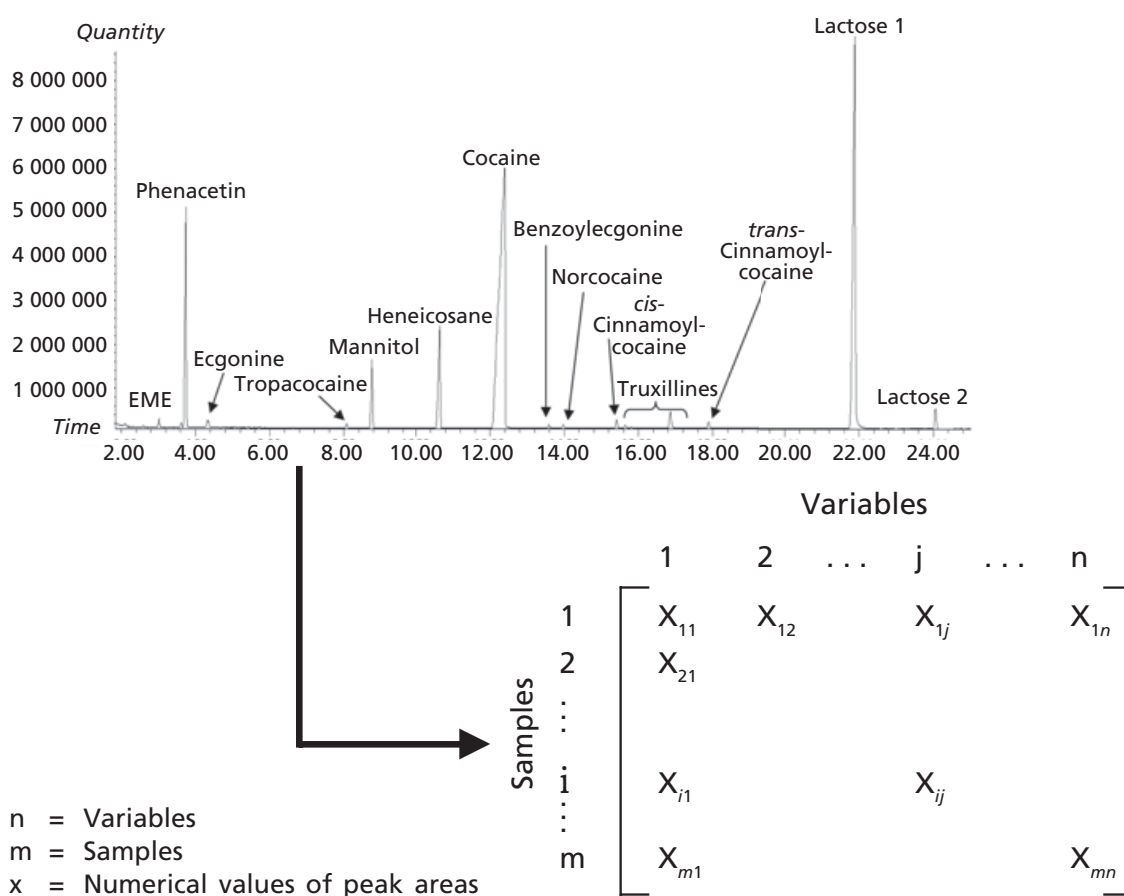
Harmonization of the analytical method

Comparability of results among laboratories

As stated above, the system's current weakness lies chiefly in the fact that a drug seizure analysed by laboratory X cannot be compared with a seizure analysed in laboratory Y unless the profiling methodology used by laboratories X and Y is identical. However, various initiatives have been introduced in recent years to harmonize the collation of information with linked physical and chemical characteristics. For example, the Fifth European Union Framework Programme

project for the development of a harmonized method for the profiling of amphetamines, [3, 4] supported by the Standards, Measurement and Testing Programme of the Directorate-General for Research of the European Commission, and project No. 97.0487 of the State Secretariat for Education and Research, brought together seven countries seeking to harmonize the profiling of amphetamines. Other initiatives include the Collaborative Harmonization of Methods for the Profiling of Amphetamine-type Stimulants (CHAMP) project for the period 2004-2006 on the profiling of Ecstasy and methamphetamines, with seven participating countries; the CASTEL project (2003-2005)* on the profiling of cocaine seized in the French-Swiss cross-border area; and the International Drug Profiling Conference, organized under the auspices of the Drug Enforcement Administration of the United States of America which dealt with heroin and Ecstasy.

Such projects form an indispensable basis for method harmonization, which is essential for the effective application of profiling in combating drug trafficking. IPS is involved in those projects and intends to use the experience gained to undertake a similar initiative encompassing the entire territory of Switzerland.

To return to the example of case A, cited above, the heroin blocks had been analysed by a laboratory in the canton of seizure. The lack of an operational programme for method harmonization led the investigator to have the substance analysed a second time in order to compare it with previously selected samples, that is, samples taken from other seizures made within the same criminal network.

In case B, a cocaine seizure took place in a canton that transfers all its samples to IPS. A person from the suspect's family living in the south of France was arrested by the French police for possession of cocaine. When that information reached the Swiss investigators, they asked for the two seizures to be compared. The cocaine seized in France was forwarded so that a comparison could be carried out.

Conceptual interpretation model

### Concept of linkage and chemical and physical links

Various types of links can be established between different drug seizures. [5-7] Linkages can be made through chemical and physical profiling or through circumstantial information from police investigations. A chemical link is established when two samples are judged to have similar profiles according to previously defined criteria, as described below. Under the methodology currently used at IPS, a chemical link is defined as the most elementary level indicating a single production batch. Because seizures taken directly from clandestine laboratories are not available (the laboratory's technique is aimed primarily at heroin- and cocaine-type drugs), the intra- and inter-variability study was carried out using large-scale seizures.

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*French-Swiss project, entitled "Apport scientifique à la lutte contre le phénomène transfrontalier de stupéfiants: mise en réseau de l'information", a part of the INTERREG III project.

To operationalize the concept of linkage, various mathematical distance-measuring and correlation methods were assessed. That research indicated that the correlation measurements (Pearson correlation and the cosine correlation) had the best potential for differentiating samples belonging to the same seizure from samples taken from seizures with different chemical profiles.

The strategy for detecting linkages was defined as follows [8, 9]. Samples taken from a common source were selected and compared with each other. The common source (the production batch) was defined as samples taken from a single seizure and having similar chemical profiles. That procedural step makes it possible to evaluate the intra-variability of a production batch. Inter-variability is evaluated by selecting samples that have been taken from different seizures and that have different chemical profiles and then carrying out the same comparison procedure that was used for the first group. Figure VI shows the results of those comparisons.

Figure VI.   Correlation values of inter-variability between unlinked seizures and correlation values of intra-variability
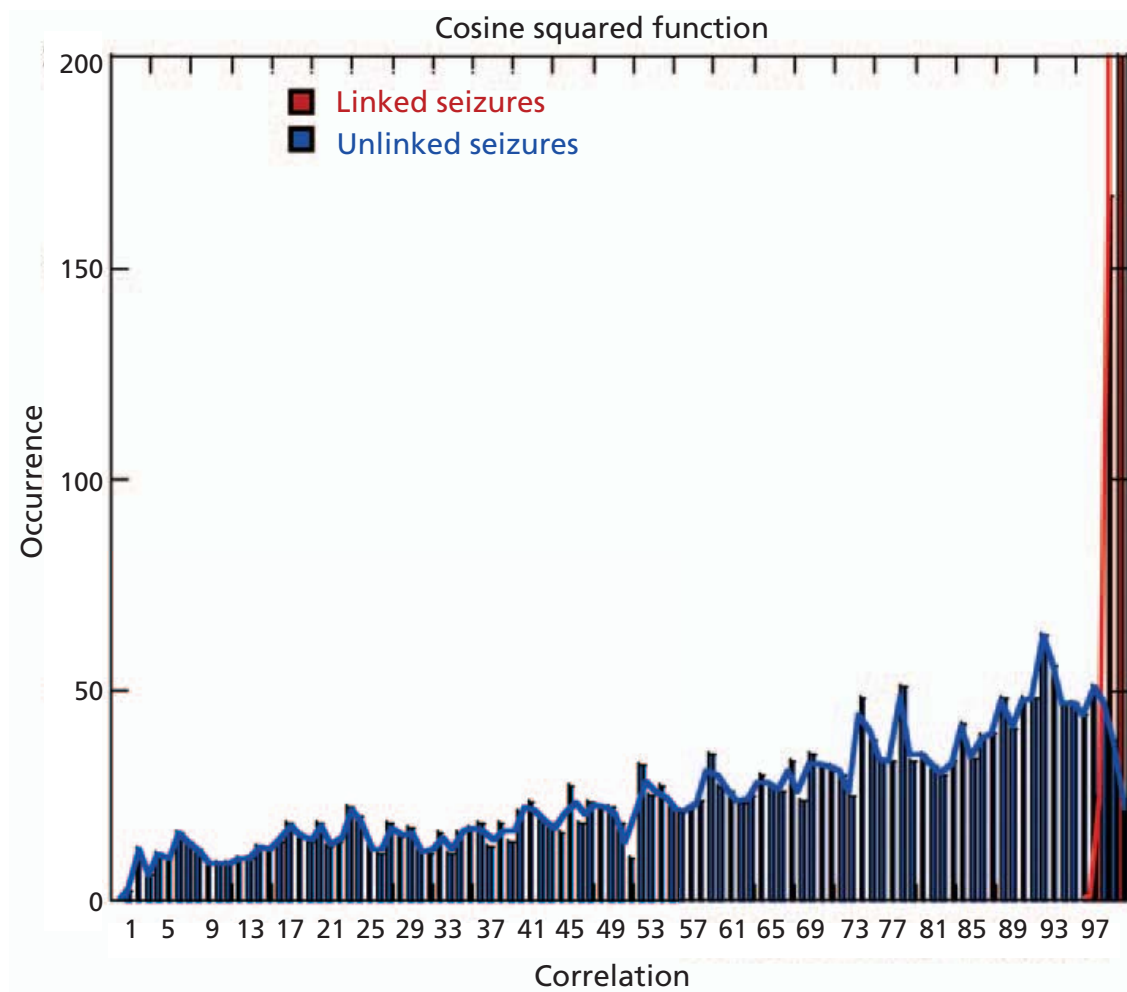
Based on those observations, a threshold value can be extracted, giving an indication of whether two samples are from the same production batch.

Figure VII.   Expansion of curves of correlation values obtained for linked and unlinked samples using cosine squared function
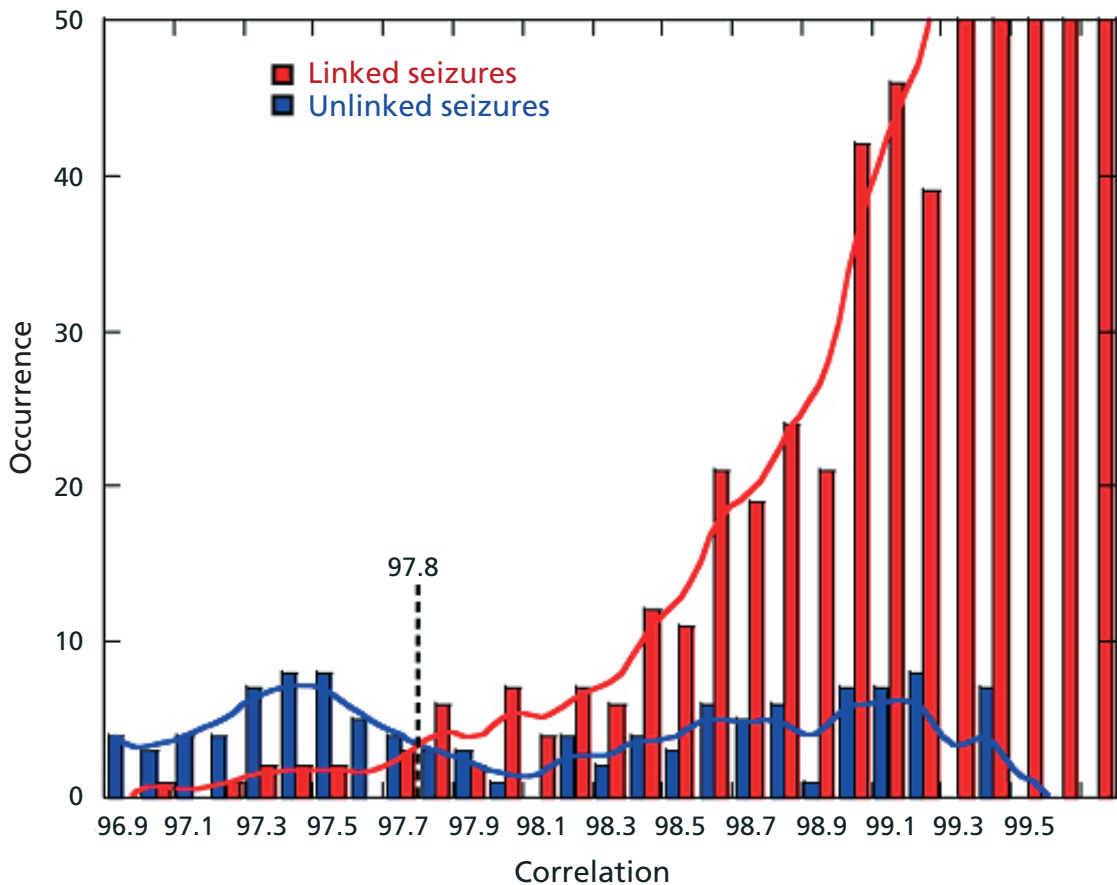
Grouping according to chemical class is the most effective way of recording samples with similar chemical profiles. That requires criteria for measuring similarity in order to determine whether two drug seizures possess a degree of similarity meeting the threshold fixed by the scientist according to his or her initial hypotheses. In the case being examined, the initial hypothesis stated that analysing a large drug seizure makes it possible to establish the statistical criteria for determining whether a sample belongs to a given production batch. The chemical class can provide information on whether seizures belong to the same production batch or the same distribution network. Such an approach can be applied to any type of organic or inorganic variable used for profiling analysis. Samples with similar logos, for example, can be grouped in the same physical class, based on their physical profile. However, without any samples of known origin, the level of linkage cannot be located without certainty.

Combining those classes with related police data makes it possible to corroborate intelligence derived from detected linkages. That stage is described below.

Database

The technique adopted is based on the systematic profiling of all drug samples entering the Institute [10] (focus on intelligence purposes). This

procedure is preferred to case-to-case comparison (focus on court purposes), which is the method most frequently adopted by laboratories conducting drug profiling work.

The case-to-case comparison process directly responds to judicial requirements, in cases where comparison assignments are clearly defined by the judge or investigators. In those cases, seizures to be compared are pre-selected, and no comparison with a comprehensive database is performed, unlike the technique adopted. The existence of a comprehensive database makes it possible to search for links between samples stored in the database memory in order to reveal unsuspected connections. The memory groups together cases that have been previously analysed and organized according to predefined physical and chemical classes.
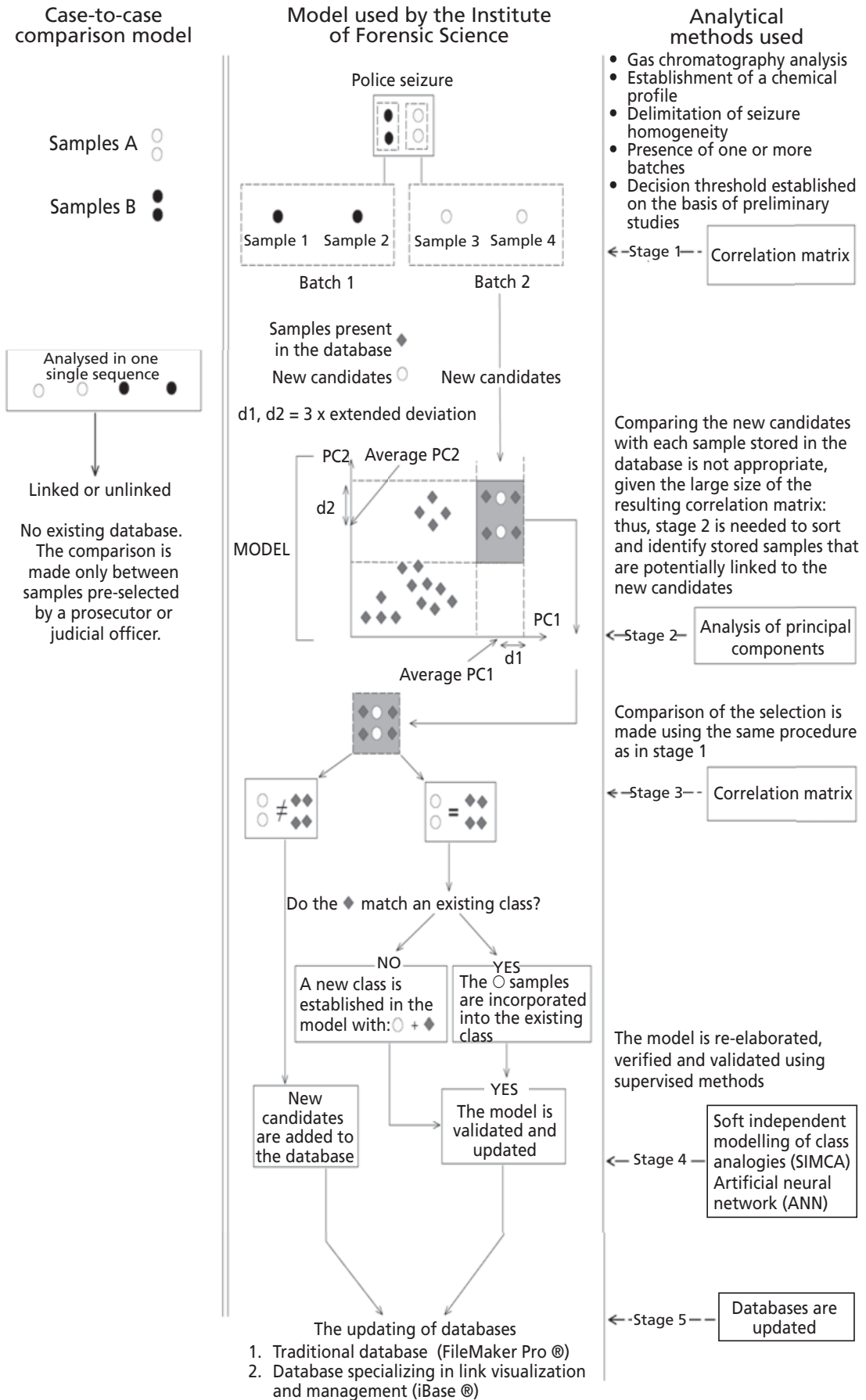
Figure VIII below, represents the comparison procedure carried out for each new entry. First, the characteristic variables of the drug's profile are entered in the system's memory, whose structure is provided by a database developed using FileMaker Pro®. The first step is to determine whether the seizure is homogenous (belonging to a single batch), or inhomogeneous (made up of several separate batches). In the second step, samples from each batch are compared with the database memory in order to select the samples contained in the memory that have chemical or physical characteristics similar to the new candidates for comparison. Principal component analysis is used to make a pre-selection. The pre-selected samples are then compared in detail using correlation measuring methods to assess similarity. The third step is sample-by-sample comparison enabling the experts to determine whether a link among the target samples can be established using the method described above [11].

The analysis carried out in the third step has three possible outcomes. In the first, new candidates have no link with samples in the memory; in that case, the new candidates are added to the memory, which is updated. In the second, samples compared are linked to samples in the memory that already belong to a chemical class, the new samples are classified as part of that specific chemical class. In the third outcome, if new candidate samples show links with samples that are in the memory but do not belong to a chemical class, a new chemical class is established.

Classification of samples in an existing chemical class entails a validation phase, the fourth step, which is carried out using supervised statistical methods such as soft independent modelling of class analogies or artificial neural networks. Those methods enable the various chemical and physical classes to be modelled. That way, new candidates can be compared with the models to confirm whether they belong to an existing chemical class. If a candidate is validated, it is assigned to the corresponding class, and the model is redeveloped. The same process for updating is carried out when a new class is identified.

Finally, in the fifth step the different database types, that is, the databases for data storage and specific databases used to manage and visually represent physical and chemical links, are updated to take into account the classifications made in the above-mentioned steps.

Figure VIII.   Procedure for establishing chemical links: two different models

Case-to-case comparison model

Samples A

Samples B

Analysed in one single sequence

Linked or unlinked

No existing database. The comparison is made only between samples pre-selected by a prosecutor or judicial officer.

Model used by the Institute of Forensic Science

Police seizure

Sample 1   Sample 2   Sample 3   Sample 4

Batch 1   Batch 2

Samples present in the database
New candidates   New candidates

d1, d2 = 3 x extended deviation

PC2   Average PC2

d2

MODEL

PC1

d1

Average PC1

Do the ♦ match an existing class?

NO
A new class is established in the model with: ○ + ♦

YES
The ○ samples are incorporated into the existing class

New candidates are added to the database

YES
The model is validated and updated

The updating of databases
1. Traditional database (FileMaker Pro ®)
2. Database specializing in link visualization and management (iBase ®)

Analytical methods used

- Gas chromatography analysis
- Establishment of a chemical profile
- Delimitation of seizure homogeneity
- Presence of one or more batches
- Decision threshold established on the basis of preliminary studies

← Stage 1 ─ ─   Correlation matrix

Comparing the new candidates with each sample stored in the database is not appropriate, given the large size of the resulting correlation matrix: thus, stage 2 is needed to sort and identify stored samples that are potentially linked to the new candidates

← Stage 2 ─   Analysis of principal components

Comparison of the selection is made using the same procedure as in stage 1

← ─Stage 3 ─ ─   Correlation matrix

The model is re-elaborated, verified and validated using supervised methods

← ─ Stage 4 ─   Soft independent modelling of class analogies (SIMCA) Artificial neural network (ANN)

← ─Stage 5 ─ ─   Databases are updated

To return to the example of case A, cited above, the samples of the heroin seized at the Swiss border were analysed a second time, at IPS. They could then be compared with the samples from that case that had already been forwarded, analysed and stored in the memory. Those steps are not performed under the case-to-case comparison procedure used in other laboratories. Where analysis is to be performed, samples selected by the investigator should all be analysed at the same time.

Management, visualization and application of linkages

Tools for managing and visualizing links

Disseminating information on chemical links established by the procedure described is crucial and requires the rational and consistent management of such linkages [5]. The test is well performed using software specially designed to manage this type of data (iBase®) and display it (Analyst's Notebook®).

Database structure

Each sample is entered in the database, including details of the type of substance found, its purity, cutting agents and its chemical class, which consists of samples with the same chemical profile (see figure IX).

Figure IX. Database structure
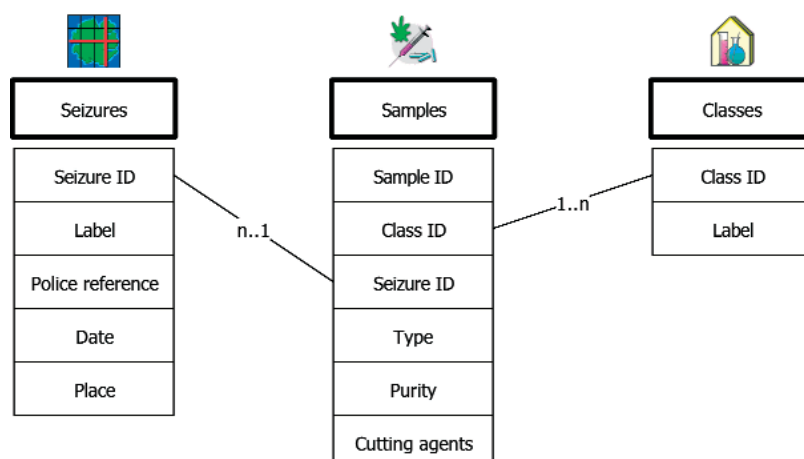
The sample is the basic unit in the management of links. That basic level provides the basis for the general level which defines the sample's relationship to a seizure (circumstantial data) and to a chemical class (analytical and chemical data). Chemical classes are linked directly to the samples taken from a seizure and not to the seizure itself. A seizure can yield samples with different chemical profiles. In that case, samples are grouped accordingly and are linked to different chemical classes. Figure X shows how such relationships can be visualized using Analyst's Notebook, a software programme that has a dynamic,

bi-directional connection to the database. In addition to visualizing entities and their connections, the software automatically updates the database according to any modification made to the visual representation.

Figure X.   Representation of linkages
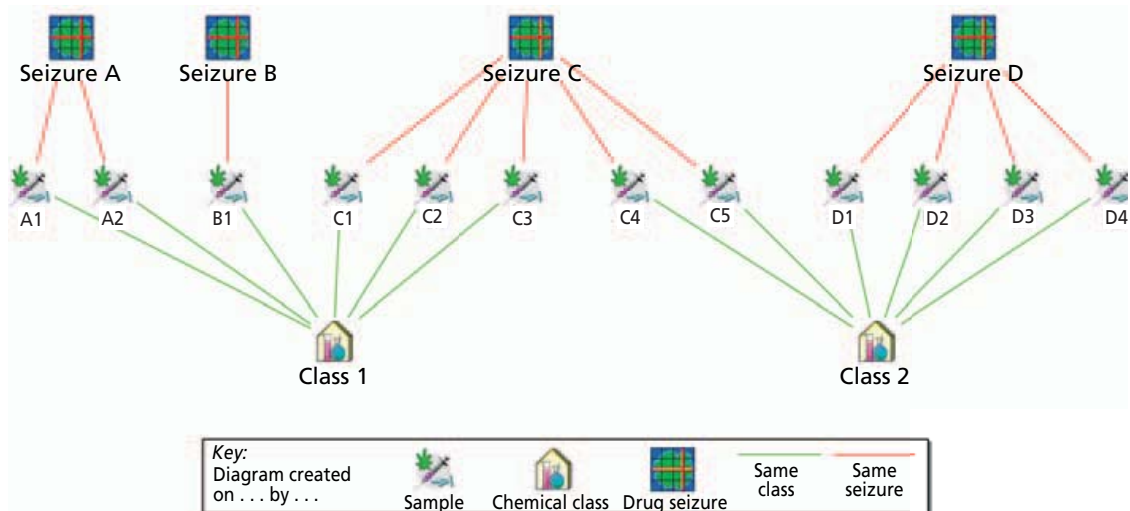
Note: Seizure C forms two groups. Samples C1/C2/C3 and C4/C5 have different chemical profiles. The first group belongs to chemical class 1, and the second group to chemical class 2.

Seizures constitute another recorded entity. The information entered on seizures comprises, inter alia, the label given to the seizure, its police reference and the date and place of seizure.

Exploitation of linkages: inference structures

Clearly, grouping chemical and physical links according to class has great potential for describing phenomenon and series. It is, however, important to bear in mind that, because of the complexity associated with their entities, such databases cannot be used in the same way that automated fingerprint identification systems or DNA databases can [12]. Databases of the latter type are effective in identifying the source of trace evidence: for example, matching a suspect's DNA to the trace evidence found at the crime scene. In contrast, in a database for drug profiling, two samples with a similar chemical profile can be linked at any point from the production stage to the distribution stage.

Using links to corroborate police information

In the course of a police investigation of a drug distribution network, investigators obtain large amounts of circumstantial information. On the basis of those data, they infer and define links that may exist between different persons active within a distribution network. Linkages revealed using such traditional methods of investigation can be corroborated and even substantiated by the detection

of physical or chemical links, which can, in turn, be used to reveal previously undetected investigative links, as described below.

The example given in figure XI illustrates those observations. In case X, the investigator concluded that seizures A, B, C, D and E were part of the same criminal network. Those five seizures and the related investigative details constituted the police view of the trafficking network. Linkages detected through chemical profiling then revealed that seizures B and D were connected through seizure C, whose samples belonged to the same chemical classes as seizures B and D (see box 1 of figure XI). The investigator's view of the links between seizures B, C and D was thus corroborated by profiling.

That example demonstrates the importance of sampling. Seizure C produces samples belonging to three separate chemical classes. It is unlikely that a chemical class would have been identified if sampling had not been carried out. That omission would have resulted in a loss of information. For example, the chemical class in the middle of box 1 was shown to be linked to another seizure, thus providing a broader view of the trafficking network. If seizure C had not been sampled, that information would have been lost.

An example of the interaction between links obtained from chemical profiles and police data is represented in figure XII. Figure XII shows the links established by monitoring telephone calls through call billing data. An informer has notified police that the two suspects contact each other indirectly using telephone booths located at the buying and selling places frequented by them. Figure XII shows the number of calls and the call direction. The analysis of the telephone monitoring clearly corroborates the information given by the informer (see box 1 of figure XII), and the drug seizure analyses confirm that hypothesis, because they reveal that the investigated individuals were in possession of samples belonging to the same chemical class (see box 2).

The converse order of corroboration is also possible. Data from police investigations can link two chemical classes that were established to be different by the laboratory's analytical methods and criteria. Thus, the two sources of information complement one another in building a view of a network and its operation. The interaction of police investigation and drug profiling data enables the database memory, and the inferences that can be drawn from it, to be kept up to date. Interpreting the results obtained by investigators in the light of physical and chemical links is key to advancing the reasoning that produces valuable intelligence.

Example

In case 1, of Figure XIII, cocaine was found inside fans at the time of seizure A. It emerged that all the samples taken from that seizure belonged to the same chemical class, as did the samples from another seizure of fans, seizure B, which took place a few days later. The two sources of information, the packaging and the chemical class, matched. Six months later, a further seizure, seizure C, was made at a dealer's home. Samples from that seizure were shown to belong to

Figure XI.   Investigation of a complex drug network
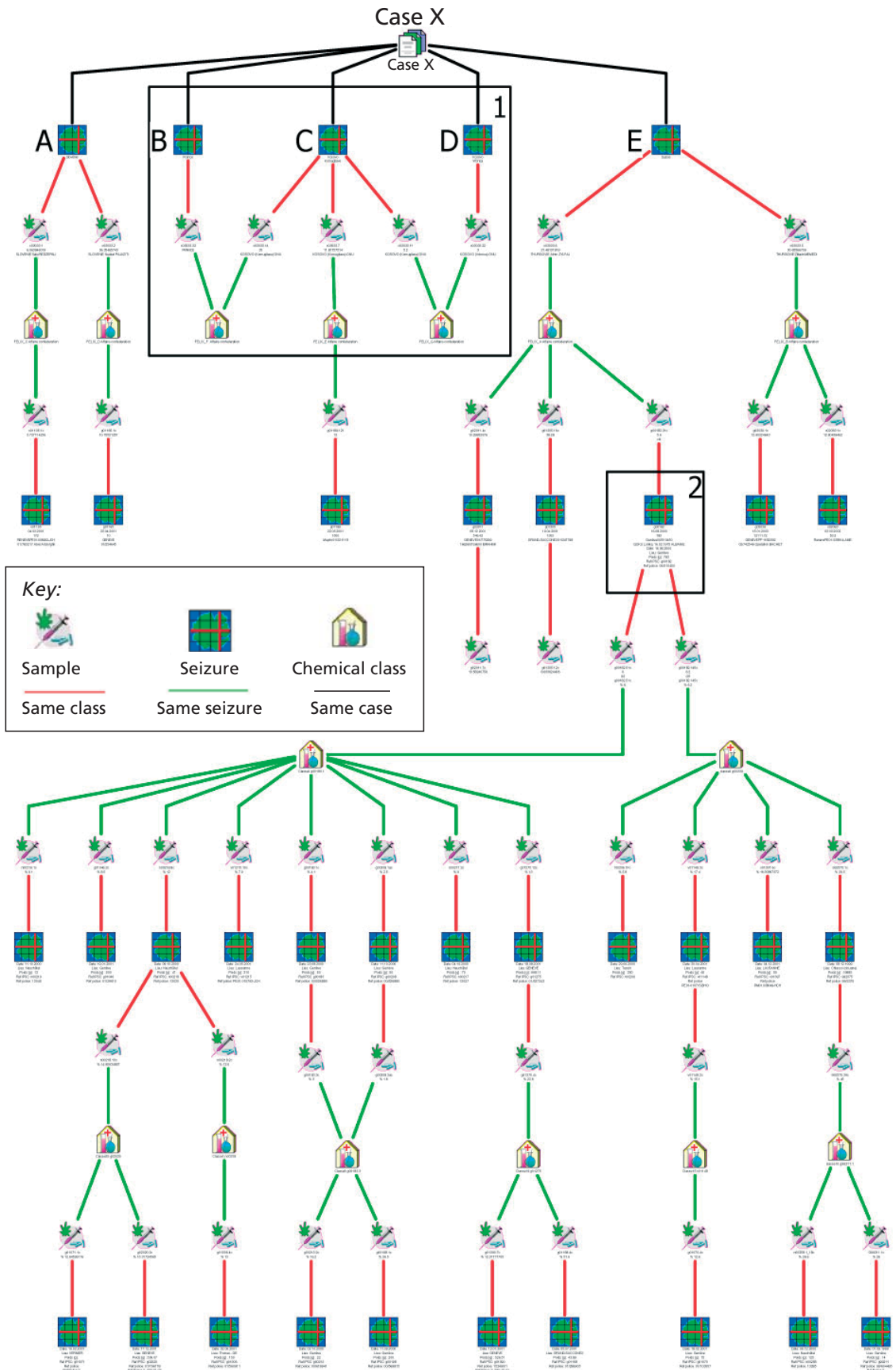
Note: Box 1 illustrates an example of corroborating investigative data. Box 2 illustrates how an important link provided by drug analysis leads to the prioritization of police investigation.

the same chemical class as the samples taken from the earlier seizures A and B. In the new case, because of its uniqueness, the packaging could be used as a marker of a drug distribution network. The fact that all samples from seizure C belonged to the same chemical class alerted the investigator to the fact that the same distribution network was probably active once again.
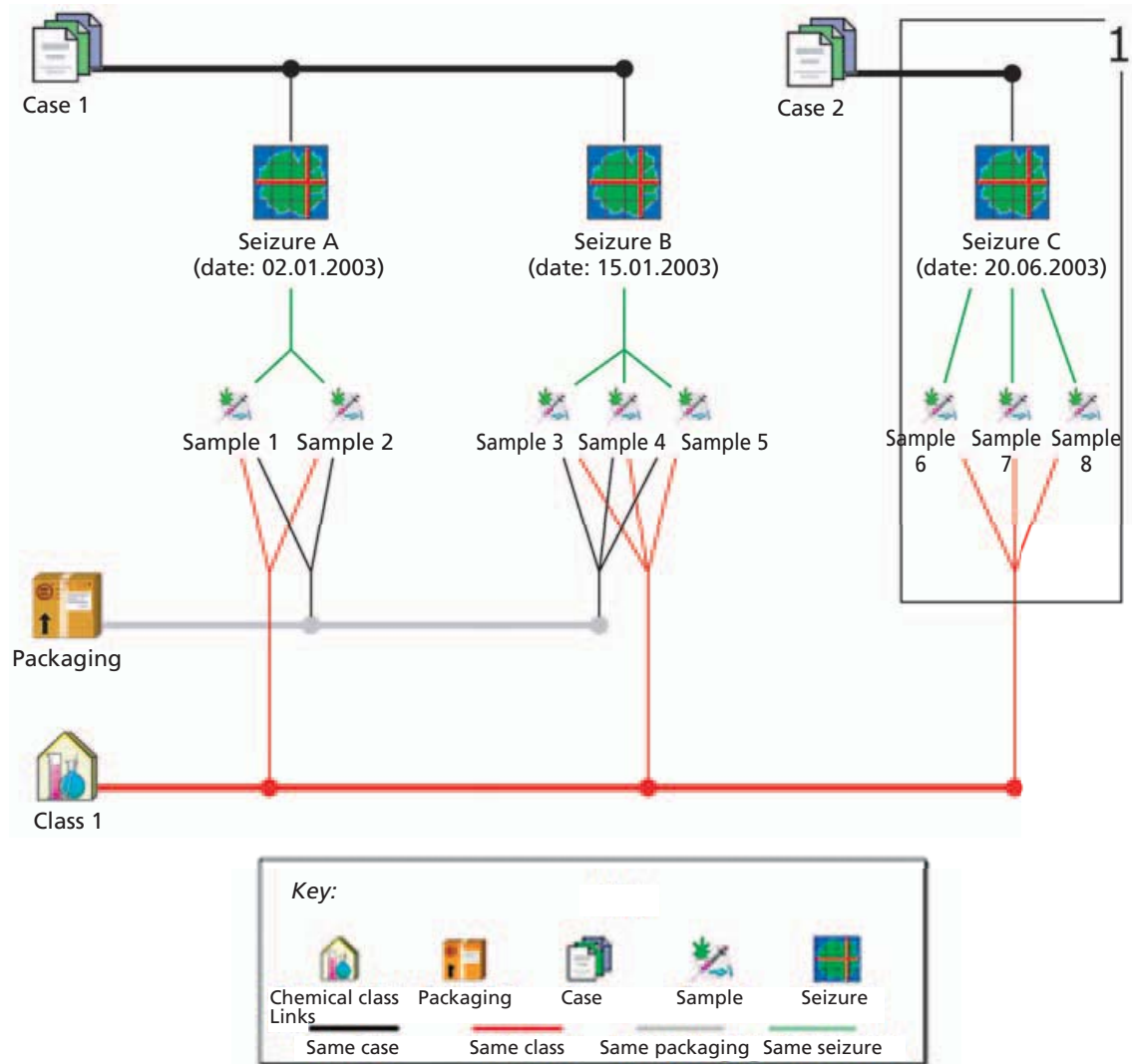
Figure XII.   Integration of police data
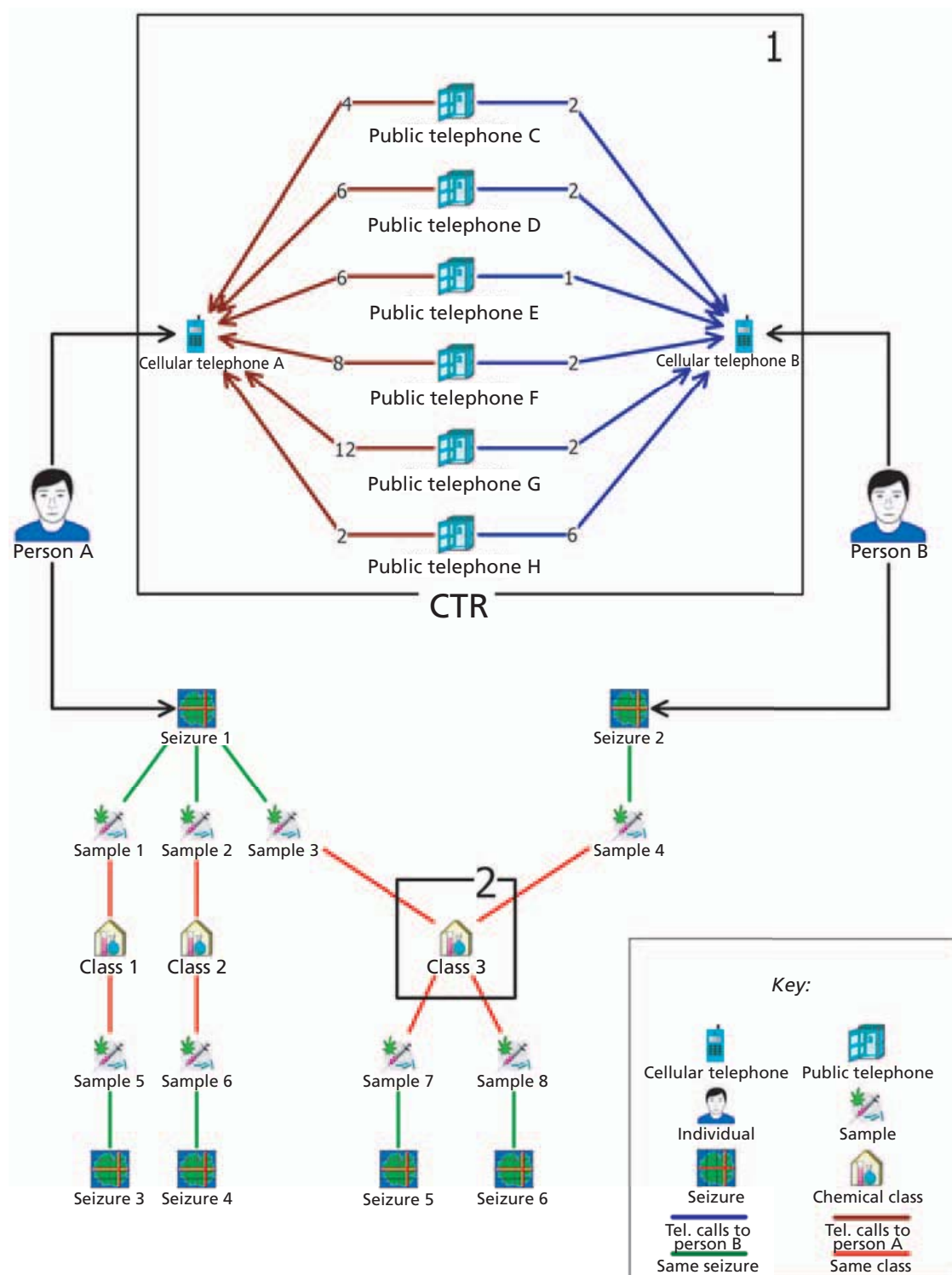
Figure XIII.   Importance of investigative data for linking seizures over a six-month period

## Using links to guide investigations and suggest priorities

The visualization of links between several seizures can take an investigation in a previously unexplored direction. Establishing links can also lead to new investigations or decide the priorities for action when an individual is found to be linked to other individuals and plays a key role in a specific market. Links can uncover associations that are not detected by regular investigative methods owing to concealment efforts of users and traffickers.

Box 2 of figure XI highlights a seizure yielding several samples with various chemical profiles. The seizure is the only entity in that case that links the top and the bottom of the chart. Thus, the individuals connected to that seizure are of greatest interest, because they appear to play a key role in the overall case.

Estimating the extent of trafficking

Data on chemical profiles, including cutting agents, and physical profiles, including information specific to tablets, can be used to estimate the length of time a batch was distributed, its total size and its geographical distribution. Figure XIV shows the lifespan of different batches. The length of the horizontal lines is proportional to the time period during which the chemical class was observed, while the thickness of the horizontal lines is proportional to the quantity of the drug seized.

Figure XIV. Estimated lifespan and total marketed quantity for six chemical classes
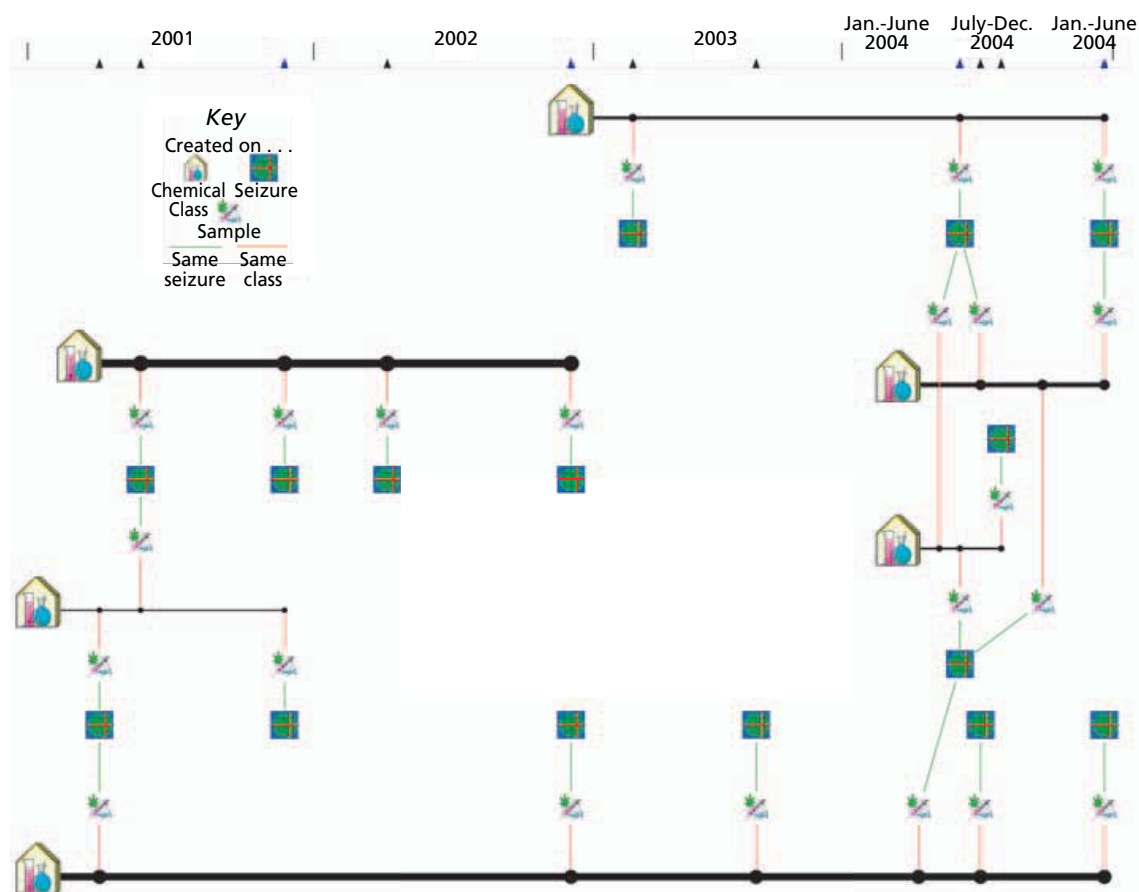

Cutting agents

Most drugs are sold in powder form, which makes it possible to add cutting agents at any point in the drug distribution process. With the resulting increase in volume, more doses can be sold, and revenue can be increased. The profile of cutting agents can thus change at each stage in the chain leading from the producer to the dealer, via the wholesaler. The methodology used at IPS can identify production batches by analysing the principal component, heroin or

cocaine. Batch purity and the combination of cutting agents provide information allowing hypotheses to be made about the stage in trafficking to which the seizure belongs.

In the case of tablets, the process of adding substances ends at the tabletting phase. Once pressed, tablets can no longer be altered. They contain excipients or cutting agents, which are used to facilitate tabletting or to increase the drug's weight for reasons of profit. Hypothesized links for such substances are thus different from those made for drugs in powder form: linkage stops at the compression stage, as shown in figure XV. Thus, when a pill contains a sufficiently differentiated chemical mixture, it is possible to trace a line back to the tablet-making laboratory, which may be either the synthesis laboratory, if it is equipped with a press, or, as shown in figure XV, a different laboratory specializing in pressing tablets.

It should be noted, however, that the presence of different mixtures does not mean that the tabletting stage took place at a different laboratory. It could simply mean that the producer obtained supplies elsewhere.

Figure XV.   Stages in the manufacture of Ecstasy tablets
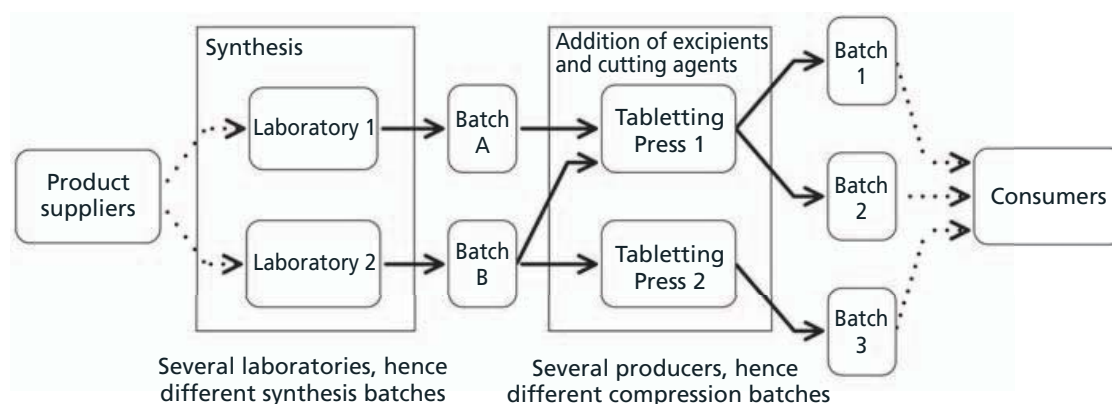
Note: Batch 1 and batch 2 have the same logo but not the same chemical profile. Batch 2 and batch 3 have the same chemical profile but not the same logo.

Communication of information

Visualization: optimizing data usage

The combination of iBase® and Analyst's Notebook® makes for an excellent tool for visualization and interpretation. Given the different entities it can record, such as seizures, samples and physical and chemical classes, iBase® allows all linkages related to a specific element to be developed. Sample results are presented in figure XI and figure XII.

Training

The main difficulty in implementing such a process is finding suitable operators to manage and interpret the new data. Although the analysis of the data is intended for use by drug team investigators, it would be unrealistic to ask them to manage such data, for two main reasons. First, from a purely practical standpoint, they already have a heavy workload. Secondly, the information is highly complex. That complexity calls for specific training and time to realize the full potential of this new tool.

Ideally, a crime analysis unit would be established to centralize, analyse and redistribute information. Such a unit could put forward hypotheses concerning the structure of criminal associations and explain their connections. The unit could make the most rational use of such data, adopting a deductive approach to formulate working hypotheses, which would be evaluated using collected information and data from law enforcement investigations.

Linkage management and interpretation may be represented in diagram form as shown in figure XVI.

To summarize, the different linkages managed in iBase® provide an up-to-date view of trends in the distribution market for drugs targeted by the police. When a distribution network is detected and a related sample drug class can be established, links can be made between different seizures. Drug seizures can then be connected with the persons involved, and a picture of the actual situation that is as accurate and as complete as possible can be obtained. The process of managing linkages between drug seizures enables police to set priorities for action and have consolidated information on the scope of a trafficking network at the time of an arrest. All that can be done provided that the chemical linkage data are obtained quickly.

Prospects

The profiling technique described in the present article is currently used in the IPS laboratories at Lausanne on a regular basis. It combines analytical methods for establishing physical and chemical profiles with management and visualization tools. In addition, detected chemical links are systematically transmitted to law enforcement authorities. Each year, a three-person team analyses, on average, 250 seizures involving some 2,000 drug samples. In approximately 20 per cent of cases, a chemical link (a relationship to another sample of the same chemical class) is detected and communicated to the investigators dealing with the case. Specific profiling procedures have also been applied to particular cases and are combined with the material evidence and the type of information more traditionally used in judicial investigations. Experiences using the linkage process described illustrate the rich intelligence potential offered by chemical links. However, aside from routinely reported chemical links, mechanisms for sharing information with law enforcement authorities have not been adequately established and are activated only sporadically. That lack of formal mechanisms

results in a loss of information. Accordingly, development efforts now focus on ways of achieving a more systematic integration of profiling intelligence from both the operational and strategic perspectives.

Figure XVI. Management and interpretation of chemical links
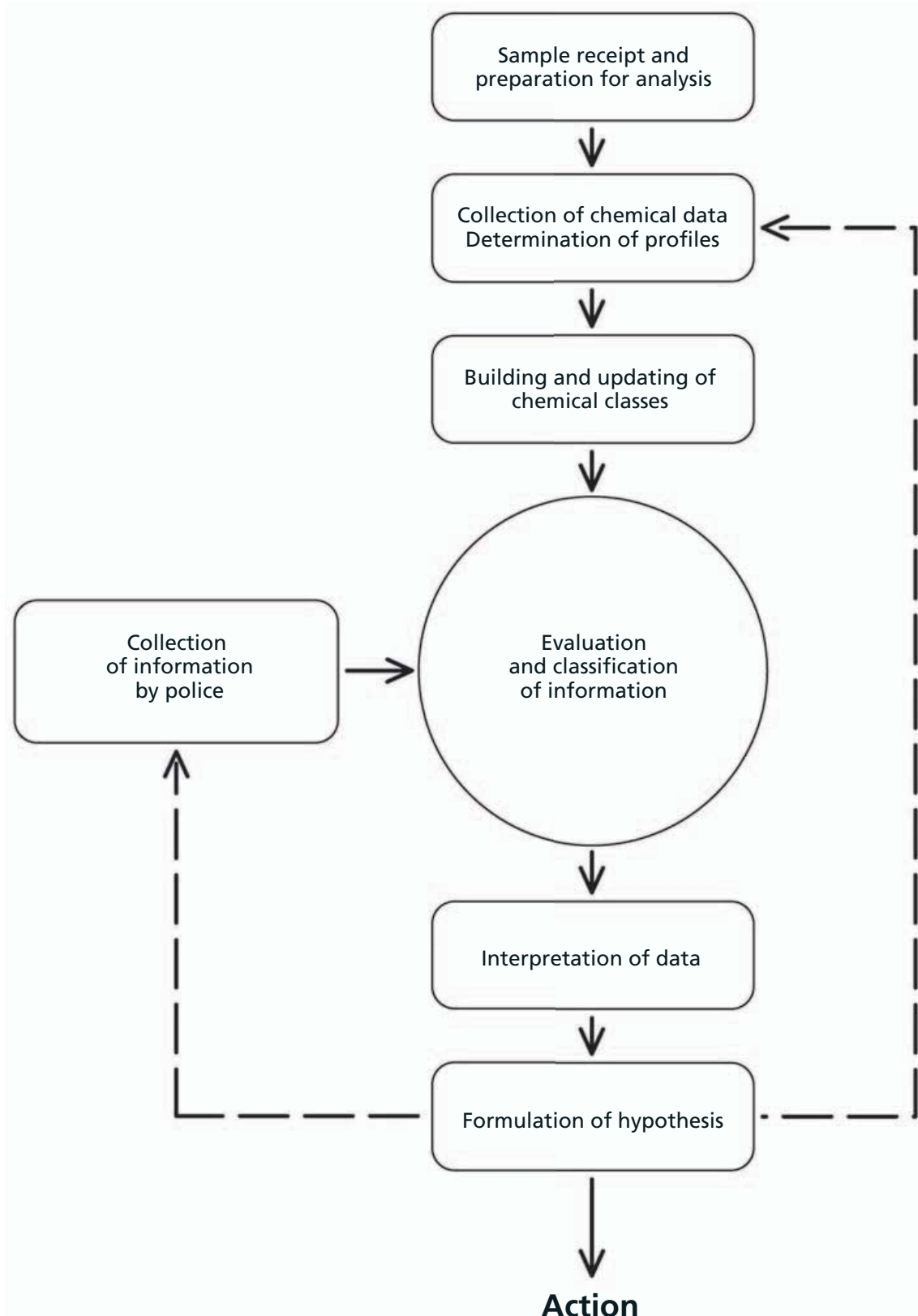
In order to better define the cooperation needed between law enforcement officials and scientists in global problem-solving, a number of specific cases are currently being handled in collaboration with law enforcement authorities. Each of those experiences is analysed in conjunction with the relevant chemical and physical information in order to identify patterns that can be used in a more systematical fashion.

One development has been the addition to the central law enforcement database of a dedicated field showing links detected through drug analysis. A judicial investigator who finds items of information relative to his case will automatically benefit from profiling intelligence. However, to complement such innovations, law enforcement officials should also be familiarized with those new sources of information, because transmitting profiling data to them from the laboratory directly without further commentary would achieve only limited results.

The field of policing is undergoing fundamental transformations, essentially driven by the development of new technologies, economic constraints and a general awareness of the clear links that exist between organized crime and terrorism. Intelligence is becoming the key element of operations. Intelligence-led strategies, in which information derived from physical and chemical links plays a crucial role, have not yet been widely implemented in the combat of illicit drugs in Switzerland. However, it appears that several entities for drug analysis in the country are starting to endorse this proposed approach. That trend is an encouraging sign for the development of drug profiling in the national context.

Conclusions

The present paper provides a description of the profiling process developed at IPS. The originality of the process is its focus on an operational approach of direct use to the drug investigation teams of local law enforcement authorities. The method of drug profiling, including analytical, statistical and computerized methods, was tested and developed with the aim of rapidly identifying linkages between drug samples. The challenge was to manage those chemical links in a consistent manner and to provide an optimal visual representation of those links, which is essential to interpreting and disseminating that data. That work has helped demonstrate that the identification of linkages between seizures in different regional markets has enormous potential for police investigations.

The methodology and the prototype introduced have proved effective, enabling large numbers of samples, some 3,000 heroin samples and some 2,800 cocaine samples, to be processed. The promising results have been confirmed and utilized by judicial authorities. The next step is to focus on implementing the model on a more systematic basis and, if possible, at the national level and even the international level. This will be necessary to gain the maximum potential of intelligence from detected linkages. Also, the linkages established cut across the various cantons whose samples are analysed by IPS.

Large-scale heroin seizures carried out in the canton of Tessin have been shown to be linked to samples from seizures made in the cantons of Geneva, Vaud and Neuchâtel. It has been shown that, through the Swiss distribution network, drugs entering via Tessin supply the Berne and Zurich areas, which, together with the Basel area, constitute the major centres for drug storage.

Thus, it seems that the current view must be broadened in order to better assess the size and the mechanics of the Swiss market. In the opinion of the authors, that requires the establishment of a unit responsible for gathering such information and forming a more comprehensive picture of possible connections between the various cases.

The need for the harmonization of data transmission and accessibility was taken into account in creating the new JANUS database of the Federal Criminal Police. That computerized system, which is used by all Swiss police authorities, pools intelligence on organized crime, including counterfeiting, traffic in human beings, economic crime, money-laundering and drug trafficking. In 2005, drug profiling was integrated into that system. That development constitutes a significant advance in the use of chemical links derived from drug analysis. It is believed to be the first database to combine traditional police information and profiling data in a single structure.

That initiative makes it possible to study connections between those different sources of information and formulate hypotheses on the structure of markets or trafficking networks (validation, significance and phenomena).

In conclusion, links established through profiling, combined with traditional information, can be used to better understand the market's structure and implement medium- and long-term investigation strategies. An investigator will thus have at his or her disposition a diagram showing all seizures chemically linked to a seizure. That approach, which combines investigative data with data from physical and chemical analysis, requires the establishment within police services of an entity capable of managing such information.

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