THE ANALYSIS OF ECSTASY TABLETS IN A FORENSIC DRUG INTELLIGENCE PERSPECTIVE

Thèse de doctorat

présentée à l’Institut de Police Scientifique (IPS)
de l’Université de Lausanne

par

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Lausanne, 2005
To my parents

and my sister

“Labor omnia vincit improbus”
Virg. (Georg., I, 145-146)
Ce travail a été réalisé entre 1996 et 2001 à l’Institut de Police Scientifique et de Criminologie (IPSC) de l’Université de Lausanne sous la direction du Professeur Pierre MARGOT. Il a ensuite été rédigé accessoirement à mon nouvel emploi à la police de la ville de Zurich. Entre-temps, une réforme des structures de l’Université de Lausanne a rassemblé dans l’Ecole des Sciences Criminelle (ESC), l’Institut de Police Scientifique (IPS) et l’Institut de Criminologie et de Droit Pénal (ICDP). Le jury était composé

- du Prof. Olivier RIBAUX, Professeur extraordinaire à l’Institut de Police Scientifique, président du jury ;
- du Dr. Erkki SIPPOLA, Directeur R&D du National Bureau of Investigation, Crime Laboratory à Vantaa, Finlande ;
- du Dr. Olivier GUÉNIAT, Chef de la police de sûreté du Canton de Neuchâtel ;
- du Dr. Jean-Luc VEZ, Directeur de l’Office fédérale de la Police.

Je remercie tous les services de police et autorités judiciaires qui ont favorisé la réalisation de ce travail en mettant à disposition une grande partie de l’échantillonnage étudié dans cette recherche, en particulier les services de la police cantonale du Tessin, de la police de la ville et du canton de Zürich, de la police du canton de Neuchâtel et de la police du canton de Genève.

Je tiens à exprimer ma vive gratitude aux personnes qui m’ont aidé par leurs conseils et leur soutien durant cette recherche et la rédaction de cette ouvrage, en particulier :

Monsieur le Professeur Pierre Margot, directeur de l’École des Sciences Criminelles, directeur de thèse, pour m’avoir donné la possibilité et les moyens d’effectuer cette recherche à Lausanne et pour la confiance qu’il m’a témoignée tout au long de ce travail.

Monsieur le Docteur Olivier Guéniat pour m’avoir initié au domaine de l’analyse des stupéfiants et en particulier au profilage des stupéfiants, influençant de manière déterminante les orientations initiales de cette thèse.

Monsieur le Professeur Olivier Ribaux, professeur extraordinaire et premier collègue de bureau pour les précieux conseils et remarques durant ce travail et pour tout le temps passé ensemble dans des discussions « forensiques » passionnantes.

Mes amis et collègues du groupe stupéfiants de la première heure, Pierre Esseiva, Eric Lock, Frédéric Anglada, Till Goldmann et Laurence Dujourdy pour l’enthousiasme qu’ils m’ont transmis pour les sciences forensiques et les longues heures passées dans les laboratoires à analyser les échantillons.

Monsieur le Docteur Klaus Müller pour la relecture et la correction finale du texte anglais et Monsieur le Docteur Kurt Zollinger, mon chef actuel, qui m’a toujours soutenu pendant cette longue période de rédaction.

Tous mes amis de l’IPS et en particulier mes anciens collègues de bureau qui m’ont accepté et intégré dans la famille de l’IPS et qui ont contribué au superbe souvenir que je vais garder de Lausanne.

Et finalement mes parents et ma sœur pour tout leur soutien durant ces années sans lequel cette « aventure » n’aurait jamais pu avoir lieu.
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I. INTRODUCTION

I.1. GENERAL CONTEXT

A social need for legal control of drugs of abuse developed at the beginning of the last century. This period coincides with the “Opium war” in China. In fact, the problems of opium abuse induced the United States of America (USA) to issue a call for an international conference having the purpose of reducing the abuse. As a consequence of the conference of Shanghai (1909) and of the first International Convention on Opium of 1912 in Den Haag, most developed countries began to set up their own legislation concerning narcotics [Albertini, 1998].

In Switzerland, the first legislation on narcotics was introduced in 1924 [LFStup, 1924]. The actual law on drugs of abuse is the result of a complete revision of this first law, which was accepted in parliament in 1951 [LFStup, 1951]. Changes and improvements occurred over time. In 1996 the law was brought up to date with the addition of two ordinances on psychotropic substances and precursors [Albertini, 1998], and was revised again in 2000. A complete revision of this law is currently under way.

Since the beginning of the 20th century, drug abuse and drug trafficking have radically changed. At an international level, drug production and drug use are mainly controlled by organised criminal groups. The illegal drug market represents a complex network of different actors (producers, dealers, consumers, etc.) and has its own “rules of the game” as an illegal underground industry. The rules of legal action also have changed. Political decisions have influenced the way society reacts to this illegal market. Efficient intervention is a combination of education, medical and social measures for consumers, and of repressive actions against producers and dealers. For repressive actions by the state, law enforcement agencies require accurate and detailed knowledge of the structures and traffic mechanisms of these organised criminal groups. The need for detailed criminal investigations and intelligence work is obvious.

Criminal investigations rest on the analysis of available police information. A fundamental part of these investigations is the disclosure and individualisation of links between people, objects and criminal events [Ribaux, 1997]. The interpretation of these links can provide valuable information about criminal organisations, methods, and illegal trafficking. This is the basis of criminal intelligence.

A broad variety of data is used in criminal intelligence, and these data come from different sources. Classical and historical information is mainly provided by traditional police activities, such as questioning, observation, or telephone tapping, which because of their immediacy and simplicity are still the channels most frequently used during inquiries. Beyond that, data supplied by forensic science can and should contribute to demonstrate the complex mechanisms underlying criminal activity. Such data may also be the only way to demonstrate the aggravating circumstances of “criminal organisation”. However, this type of data is still very poorly understood, its use by police services is fragmentary and to some extent even entirely ignored.

Ecstasy tablets and their illegal market are of particular interest in this context. They are made from a synthetic drug covering a wide range of illicit products; these are mainly
consumed as tablets in certain subcultures such as “rave parties”. Customers, therefore, belong to a specific segment of society.

I.2. EVOLUTION OF THE DRUG SITUATION IN SWITZERLAND OVER THE LAST FEW YEARS

The addiction to illicit drugs has dramatically increased during recent years in Switzerland, as it has on the entire European continent, and is the cause of major concern for society. The results of public inquiries show that this problem is regularly listed among such major concerns as unemployment, environment, European unity, old-age pensions or national security [ISPA, 1999]. The evolution of the number of drug-related deaths as well as of the number of illicit drug-related denunciations shows that the problem has particularly strongly increased after 1989 [OFSP, 1975 – 2003]. Between 1975 and 1994 the number of denunciations increased by approximately 600 %. The number of deaths increased by over 1000 % between 1975 and 1994, with a particularly sharp increase between 1988 and 1992. The high mortality shows that the trend is real, rather than the result of a higher police or judicial activity.

![Denunciations and deaths in relation with drugs; Switzerland from 1975 to 2003](image)

**Figure I.2.1.:** Denunciations and deaths in relation with drugs; Switzerland from 1975 to 2003.

Since 1994, an important change in the tendencies can be noticed. The number of denunciations is still on the rise, but the number of drug-related deaths has sharply and constantly decreased. A possible explanation of this sudden change is the new policy decided by the federal government in 1991. This policy comprises four strategic elements, and it is...
known as the fourfold drug policy (law enforcement, prevention, therapy, and harm reduction) [OFSP, 1999]. In addition to “classical” therapies, the federal government started a heroin-assisted treatment program, which at first was a scientific experiment for the purposes of evaluation, and later on it was introduced on a larger scale. Since the majority of drug-related deaths are due to overdoses of heroin, the decrease in the number of deaths has been attributed to this new policy. On the other hand, the number of denunciations continues to increase, which implies that the problem of drug use is still important, and still growing.

A more detailed analysis of this evolution by type of drug is shown below [OFP, 1986 – 2003]. Again it is possible to see the dramatic increase of drug cases between 1990 and 1995. In this five-year period there has been a 143 % increase of recorded drug cases. Particularly dramatic was the increase of heroin seizures. The cases of hashish seizures have constantly decreased since 1995, which is mainly due to the fact that the operational and political priority of law enforcement was shifted to the so-called “hard” drugs, that is, heroin and particularly cocaine.

![Cases of cannabis, heroin, cocaine, ecstasy and LSD seizures in Switzerland from 1986 to 2003.](image)

*Figure I.2.2.: Seizures of illicit drugs in Switzerland from 1986 to 2003.*

The next diagram shows that from about 1992 a new illegal substance has appeared on the Swiss illegal market, viz., amphetamine and its derivatives in the form of ecstasy tablets. The number of these cases quickly increased up to the year 1996 to a maximum of 1035 (involving the seizure of about 80 000 tablets).
Ecstasy seizures in Switzerland from 1986 to 2003

From 1997 to 1999 the number of cases decreased, and reached about 500 to 600 cases per year, but then suddenly increased to 974 recorded cases in the year 2000, which was the year with the maximum number of tablets seized (about 190 000 tablets). This peak of the number of tablets seized was mainly due to one big case involving nearly 90 000 tablets in the spring of 2000 in the canton of Zurich. Since then, police and judicial priorities shifted in accordance with the new drug policy. Specifically, in 1999 the Swiss Federal Court in Lausanne reached the decision (ATF 125 IV 91) introducing a jurisprudence according to which the seizure of ecstasy would not fall under the category of serious crime. De facto, the judiciary system nowadays does not consider ecstasy a dangerous drug but gives priority to investigations involving cocaine and heroin. On the other hand, the court is aware of the fact that chronic diseases may be caused by the long-term use of ecstasy, and might take this element into account in future judicial decisions which might reverse the current jurisprudence.

Ecstasy is the drug found preeminently in techno parties. Such parties are the symbol of a subculture of young people. A survey conducted in Switzerland in 1998 showed that about 5% of 15 to 30-year-old have experimented with ecstasy [OFSP, 1999]. Another relevant study [ISPA, 1999] showed that the regular use of ecstasy often begins at an early age. Nearly 50% of the ecstasy consumers started before they were 18 years old.
These data show that this drug problem is quite recent, and concerns mainly young teenagers (under 15). It is evident that, even if the initial dramatic increase did not continue, and judicial priorities remained fixed on cocaine and heroin, ecstasy and synthetic drugs in a near future might take up an important place in the illegal drug market. Recent experience with other amphetamine-like drugs such as methamphetamine (Thai pills, yaba, etc.) revealed enormous chronic health problems. Also, the link to organised criminal and underground organisations is obvious from the cases recently resolved (Thai pills linked to trade in human beings for prostitution, etc.)

It is reasonable and important, therefore, to improve the methods of investigation and the intelligence by studying this type of evidence.

### I.3. PRELIMINARY REMARKS

#### I.3.1. Introduction

This section gives an overview about the followed general research strategy and an explanation of the starting hypotheses. In fact as a fundament of the following research studies, three basic hypotheses have been recognised intuitively and enunciated as follows. These hypotheses are discussed later on according to collected results.
I.3.2. **Goal of this research**

From a drug intelligence perspective, forensic science data can provide physical evidence for links, organisations, and geographical distribution of a structure as well as evidence with a high information content that is useful in solving crime cases and targeting illegal drug-trafficking organisations.

This thesis focuses on studies of the visual, physical and chemical characteristics of ecstasy tablets, which then serve as a support for investigations and criminal intelligence. The intelligence potential of such data will be demonstrated. Various new approaches and methodologies were investigated and defined. They should be useful in acquiring further knowledge about synthetic drugs, about their manufacturing practice, and about their distribution mechanisms.

A few basic hypotheses are set down at the outset when defining the scope of this research. An initial strategy was proposed, then adapted over the years in the face of results and new knowledge [Zingg, 1999].

I.3.3. **Hypothesis 1: Information content of drug exhibits**

*All drug exhibits are a potential source of information.*

This is an obvious hypothesis serving as the basis of this research. Literature publications and practical experience confirm that drug samples can be characterised in terms of specific chemical and physical properties. These properties represent the signature of the tablet’s “personal history” and reflect the methods of synthesis of the active materials, the production of the tablets, the storage conditions and so on [Stead, 1991]. Some scientists use the analogy of fingerprints, which would imply an overly “personal” identification. This analogy is doubtful, since possible inferences could be quite different.

Particular chemical analyses of drug samples which commonly are known as drug profiling or chemical signatures or (more properly) chemometrics, which is a mathematical mean to interpret chemical signatures, make it possible to link or discriminate different samples obtained in unrelated drug seizures. Practical applications have been described, mainly where court evidence was required, and more rarely where intelligence was the purpose [Perillo et al., 1994][Jonson and Strömberg, 1993].

I.3.4. **Hypothesis 2: Representativity of the population**

The representativity of a population studied is a major concern in research. It is imperative to be certain of the true representativity of the population studied in order to correctly interpret the available data and distinguish batch variations within a given production run from variations between different production centres.
It is general knowledge that the amount of drugs seized by police services only represents small part of the allegedly large volume of the true illegal market (according to estimates, < 10 % of the total), which is a limiting factor. By adopting the following two conditions it was possible to some extent to increase the representativity of the population studied.

1. All seizures of ecstasy which have occurred over a defined period of time within a defined geographical region must be accounted for.

2. Ecstasy seizures which refer to different regions (for example, north and south of the Alps) must have occurred during the same lapse of time in order to be taken into account.

With these preliminary specifications, the following assumption was then tested:

**Drug exhibits seized by the police are representative of the illegal ecstasy market.**

More particularly, in this research the hypothesis was adopted that drug seizures in Switzerland are representative of the Swiss illegal ecstasy market.

### I.3.5. Hypothesis 3: Temporal representativity

The drug market, and especially the illegal ecstasy market, is dynamic and rapidly changing as a function of offer and demand. Additional factors are the speed of distribution and the time to depletion of a batch in the market, for example. Police activities are affected on two levels: the changing patterns of an organisation and/or the arrival of new batches without any change in organisation. The time factor, therefore, also influences illegal market research. In order to be representative on a temporal level, it will thus be necessary to limit the population in time and time intervals.

Some examples examined in the preliminary phase of this work have shown that within a period of three years it is possible to identify new drug series from the beginning to the end of their presence in the illegal market, and to define sub-entities for more detailed analysis. While production and trafficking methods are changing, however, investigation methods and the characterisation of drug exhibits can be assumed to be stable in time. The following hypothesis was made:

**Investigation methods based on forensic science are stable over time and can be used to analyse the illegal drug market on a strategic and operational level (results remain comparable over the time period).**

On this hypothesis, it will be possible to apply the methods of investigation described, not only to the illegal ecstasy market but also to other, related topics such as the illegal trafficking of LSD blotters and other drugs or even to the illegal diversion of prescription drugs (for example Rohypnol).
I.3.6.  **Research-strategy for this work**

The strategy adopted to test the above hypotheses may be divided into two major steps. In a first step, different physical and chemical characteristics of ecstasy tablets would be studied in order to see whether they are capable of differentiating manufacturers, batches, and production methods. Depending on the required level of comparison, it was important to study more closely their correlation and significance.

In a second step, the investigation methods themselves were scrutinized in order to sort out more pertinent data and gain the most valuable intelligence information. In this phase, it appeared opportune to apply crime analysis methods from the traditional intelligence process and define new ways of application specific to forensic data analysis.
II. THEORETICAL PART

II.1. SYNTHETIC DRUGS AND ECSTASY

II.1.1. Preliminary remarks

The discussion about synthetic drugs and about the production of ecstasy tablets provided below is a summary of a selected number of scientific publications that have appeared in the literature up to the year 2002, with only a few references to work published later in 2003.

The bibliographic state of the art did not change and is well described by the references listed at the end of this work. The following choice of additional recent publications completes the bibliographic overview in a precious way: concerning analytical methods of identification [Sägmüller et al., 2003][Wachowicz and Czerwinska, 2004][Shen et al., 2003] and chemical profiling methods [Bell et al., 2003][Puthaviriyakorn et al., 2002][Gimeno et al., 2002][Palhol et al., 2004][Cheng et al., 2003]; but also concerning new illicit substances and their synthesis methods [Waumans et al., 2003] or giving an overview on synthetic substances [Makino et al., 2003][Lora-Tamayo et al., 2004][Baer et al., 2003].

In this context, I am particularly aware that in more recent times an effort has been made in the chemical analysis of trace compounds, to profile the illicitly produced tablets and find batch relations between different seizures.

II.1.2. Definition of the field

II.1.2.1. Introduction

Many different terms such as drugs, drugs of abuse, controlled substances, illegal drugs, hallucinogens, stimulants, psychotropic substances, narcotics and so on are used and regularly confused in the mass media, academic and judicial literature, and everyday discussions when referring to substances or materials that are abused, illicit, and toxicologically active. Therefore, depending upon the knowledge, education, and interest of the source, there also exist a number of ways to classify illicit drugs.

This study employs the classification of illicit drugs from an analytical and forensic perspective. Illegal drugs are classified according to their chemical and physical properties and to their origin and/or manufacture (Annex 1: Classification of illicit controlled substances).

A distinction is made between products of natural origin (purified or not) and synthetic substances. Natural drugs originate from living organisms. These drugs include preparations of plants and other living organisms (such as marijuana or psilocybe fungi), substances which are extracted from the plant (such as cocaine), and also semi-synthetic compounds made from extracted substances (such as diacetylmorphine prepared from natural morphine). Usually the
cultivation of drug plants is regulated by legislation, therefore, illegal cultivation is organised and controlled by illegal organisations. In the Swiss illegal market, heroin and cocaine are the major abused and controlled drugs besides cannabis. Over the last few years, abuse of so-called “bio” drugs has increased [Berkfeld and Löhrrer, 1998].

Synthetic illicit substances (psychotropic products) are the result of chemical synthesis starting from precursors legally or illegally procured. Synthesis of these products usually requires basic chemical equipment and knowledge, as it often involves at least two-step reactions as well as particular purification procedures. Originally, these substances were found as the results of pharmaceutical and medical research. Major synthetic substances that are abused and controlled in Switzerland are amphetamine and its derivatives as well as LSD. Benzodiazepines and barbiturates are primarily regarded as remedies (prescription drugs), their abuse is monitored through national health control officers.

II.1.2.2. What are ecstasy tablets?

The term “ecstasy” or “XTC” relates to the chemical family of amphetamine and its derivatives. Current usage of these and other, related terms is often a source of contradictions caused by improper application of nomenclature.

The first report on the synthesis of amphetamine was published in Germany by Edelano in 1887 [Edelano, 1887], its stimulating properties were discovered almost 30 years later by an American chemist, Gordon Alles. The methyl-substituted amphetamine, methamphetamine, was synthesised for the first time in 1919 by the Japanese Ogata [Aldrich et al., 1978]. After initial pharmaceutical and medical research projects in which it was concluded that there were few concrete applications in medicine, amphetamines were first abused by soldiers in 1936 during the Spanish Civil War; the abuse of this drug really surged with the start of the Second World War. German, Japanese, American, and British authorities issued the stimulants to the troops. After the Second World War, its spread in the underground scene was associated in particular with the San Francisco “speed culture” in the late 1960s.

The term “designer drugs” is regularly used to describe chemical derivatives of amphetamine, and especially the 3,4-methylenedioxy-substituted phenylalkylamines such as MDA (3,4-methylenedioxyamphetamine) which was synthesised for the first time in Germany in 1910 [Mannich and Jacobsohn, 1910], or MDMA (3,4-methylenedioxy-N-methyamphetamine) which was synthesised and patented in 1914 by Merck in Germany [Patent, 1914]. These substances had initially been studied as anorexiants, and were forgotten until a group of psychoanalysts studied them again at the beginning of the 1980s [Staub, 1996]. At that time these products reached significant popularity under the name “ecstasy” or “XTC”, and were associated with the “techno and rave culture”, particularly in some British subcultures. Most of the other derivatives of MDA and MDMA (such as MDEA, MBDB or other, less successful products such as BDB, MMDA, DOM, DOB and so on) [Cyr et al., 1996][Fritschi et al., 1997] are the result of targeted synthesis in underground laboratories during the last 20 years. Particular sources of synthetic information are in the book about phenethylamines, “PIHKAL” [Shulgin and Shulgin, 1991], and in the follow-up book about tryptamines, “TIHKAL” [Shulgin and Shulgin, 1997].
The substances of this class most frequently seized are shown in the following figure.

![Chemical structures of the most frequently seized derivatives of amphetamine.](image)

**Figure II.1.2.1.: Chemical structures of the most frequently seized derivatives of amphetamine.**

In order to avoid any misunderstanding in forensic descriptions, it will be important to use the chemical nomenclature of these substances or their accepted and correct abbreviations. It is imperative not to use general street names to describe a known chemical structure, for example “ecstasy” for MDMA or “speed” for methamphetamine. In fact, street terms were only used at the beginning when a particular chemical substance became popular, and as a (slang) vocabulary recognised by “insiders”. With the advent of other, new products and for sales purposes, the same names were used and even abused to cover ineffective look-alikes. As a result, street terms relate much more to the physical appearance of a preparation than to its chemical composition.

In the “techno and rave scene” as well as in the mass media, the term “ecstasy” or “XTC” is mainly used to describe illicitly sold tablets or pills, whether they contain MDMA, amphetamine or any other related compound. Tablets which contain substances that are not controlled, and even pharmaceutical tablets, are sometimes sold as ecstasy as well. Therefore, the following definition for *ecstasy* is proposed:

**The term “ecstasy” includes all those tablets illegally produced and sold in a nonoriginal package which mainly, but not exclusively, contain synthetic amphetamine-like controlled substances.**

### II.1.2.3. Differences between tablets and powdered drugs

Contrary to the more “traditional” powdered drugs such as heroin and cocaine, ecstasy is usually sold as tablets, which are characterised by two main differentiating features.
1. Ecstasy tablets are often of a higher degree of complexity in chemical composition than heroin or cocaine powders. The active substances in ecstasy tablets cover quite a large variety of synthetic drugs, as described at the beginning of this chapter, and this cocktail is subject to continuous development. It is not rare to see new designer drugs or to discover new methods of synthesis. This variety of synthetic methods and conditions is the source of a wide range of impurities. A variety of additional substances such as excipients, lubricants, and binders are also needed for the production of tablets [Furnari et al., 1998].

2. Tablets and pills yield a broader range of information concerning their physical, morphological and visual characteristics. This information constitutes a direct description of the preparation itself, as distinguished from a physical description of packaging.

These additional, more complex data yield a more detailed and accurate picture of the manufacturing process than other investigative routes concerned with the pathway from manufacture to distribution (or laboratory to consumer). Thus, the drug exhibit itself contains signature-like information about the original criminal network.

A highly simplified and schematic comparison of the two networks is given in the figure below.

![Figure II.1.1.3.1: The traffic of powder drugs compared to the traffic of tablets.](image)

This figure indicates that powdered drug exhibits undergo greater change with time and descend over the hierarchical steps of a network. The differences between the drug originally produced and that finally seized may be considerable, and any chemical comparison may be difficult. Therefore, seized samples of the final drugs not only depend on the origin but also on the route. It is difficult then to recognise the steps involved or any changes that have occurred in the chemical profile of the sample.
Seized ecstasy tablets are not influenced by traffic, as it is not possible to add cutting agents, etc. Rarely (and mainly accidentally), external marks or stains may be left on ecstasy tablets. Ecstasy tablets therefore only reflect the chemical synthesis of the active compound and the pressing (press marks etc.), which produce particular physical and morphological characteristics as well as some chemical information. In the manufacturing process, two steps can clearly be recognised: the synthesis and the pressing of the tablet. Each of these steps leaves its “own traces” on the tablet. The steps can be performed in a single operational facility or in a complex arrangement where producers deliver to tabletting subsidiaries or tabletting industries offer an outlet to smaller producers.

From an intelligence and forensic point of view, it is very important to know the origin of all the different characteristics, as this will always yield another aspect of a particular moment in the “history” of the seized tablets. Definition of link levels will be a major concern of this study (see Section IV.3.).

II.1.3. Production of ecstasy tablets

II.1.3.1. Production of synthetic drugs

The active substances most frequently encountered in ecstasy tablets in Switzerland between 1995 and 1997 were MDMA, MDEA, and amphetamine, as shown in the following figure, which includes analysis results from 450 seizures realised in the cantons of Zurich, Ticino, Neuchâtel and some other cantons.

![Frequency of illegal substances in ecstasy tablets analysed at the IPSC laboratory in 1997](image)
In scientific publications, in the legal and underground literature and from various Internet sources, plenty of information is available about the synthesis of a broad variety of typical and unusual amphetamine-like synthetic substances. It is not the aim of this work to consider exclusively the chemical production of amphetamine and their derivatives, therefore, only an overview of the synthesis of amphetamine and MDMA will be provided.

In a chemical process occurring in one or more steps, the final product is made from starting chemicals and reaction partners, other chemical substances (such as catalysts) and solvents. Generally, the chemicals can be divided into various categories as described below [Fisher, 1997]. Sometimes no difference is made between reactants and chemicals [DEA, 1977].

**Precursors**

Substances that become the main body of the final product.

**Essential chemicals**

**Reactants**

Substances that chemically react with one or more precursors, and become an accessory part of the final product.

**Chemicals**

Substances such as acids, bases, salts, oxidation agents, and catalysts which are auxiliary chemicals in the process.

**Solvents**

Volatile substances which do not chemically react with the reactants or precursors and do not become part of the final product. Solvents are used to dissolve solid precursors or reactants, to dilute reaction mixtures, and to separate and purify.

![General reaction scheme](image)

*Figure II.1.2.1.2.: General reaction scheme.*

In contrast to pharmaceutical products, illegal preparations often are more highly contaminated. Traces in these preparations, also improperly known as impurities, largely arise from inadequate purification procedures, short cuts, lack of quality control, and can have a variety of causes such as imperfect chemical handling, impure starting materials or diluents, side and subsequent reactions, intermediate products, laboratory dirt and the handling and packaging of the drugs. Identified traces yield information about production and may establish links between seizures having identical trace content.
II.1.3.1.1.  Synthesis of amphetamine

Central to the various routes for the synthesis of amphetamine as well as that of its analogues such as methamphetamine is a reductive step at some point of the process. The following are some methods commonly used in the production of amphetamine, in which the chemical manipulations are not difficult and the necessary materials are readily purchased by underground laboratories. Many other production methods are known, but are of lesser importance [Verweij, 1989][Frank, 1983][Allen and Cantrell, 1989]. Reported reaction conditions vary widely [DEA, 1977]. Stereochemical analyses and reaction mechanisms have rarely been investigated and published [Allen and Kiser, 1987].

- The Leuckart reaction

![Leuckart reaction diagram](image)

Figure II.1.2.1.1.1.: The Leuckart reaction of amphetamine formation.

The conversion of some ketones to the corresponding amines by heating with an excess of ammonium formate was described by Leuckart as early as 1885, and has later been improved by Ingersoll and Moore. Over the years, the Leuckart reaction has remained the most popular method for the synthesis of illicit amphetamine in Western Europe. It is a two-step nonmetal reduction of phenyl-2-propanone, followed by precipitation, usually with sulphuric acid. A wide variety of different alternative conditions of this reaction are known and used by clandestine laboratories.

- The reductive amination of P-2-P

![Reductive amination diagram](image)

Figure II.1.2.1.1.2.: The reductive amination of phenyl-2-propanone.
In this reaction heterogeneous catalysis is used to reduce the imine bond of a Schiff’s base formed with phenyl-2-propanone and ammonia in order to produce amphetamine. A competing reaction, the reduction to 1-phenyl-2-propanol, limits the yield of amphetamine. Reaction conditions can differ widely, but only low-pressure and low-temperature aminations have been reported in the literature and used in clandestine laboratories so far. This reduction continues to be the most popular synthetic route for the production of amphetamine in clandestine laboratories of the United States of America.

**The oxime route**

![Figure II.1.2.1.1.3.](image)

The precursor phenyl-2-propanone reacts with hydroxylamine to give the oxime, which is hydrogenated with lithium aluminium hydride to amphetamine. Electrolytic reduction has also been reported for this synthesis.

**The phenylnitropropene route**

![Figure II.1.2.1.1.4.](image)
Basically, this is a metal-catalysed reduction of phenylnitropropene. Condensation of benzaldehyde with nitroethane in a butylamine solution yields 1-phenyl-2-nitropropene, while hydrogenation of the double bond and subsequent reduction of the nitro group gives amphetamine. In this route also, reported reaction conditions vary widely.

II.1.3.1.2. Synthesis of MDMA

In general, the single-step techniques which require little knowledge of chemistry are the ones most likely to be used in underground laboratories. Novel syntheses and more difficult synthetic routes are rarely used. Thus, it is the restricted availability of the key ketone (3,4-methylenedioxyphenyl-2-propanone) and other precursors that has forced clandestine laboratory operators to seek alternative and additional approaches to the synthesis [Verweij, 1992]. A multitude of combinations for the synthesis of MDMA, MDA and MDEA are described in the popular [Shulgin and Shulgin, 1991] and scientific literature [Dal Cason, 1990]. The preparation of MDMA from MDA is rarely reported [Dal Cason, 1990]. The four most common synthesis routes for MDMA are summarised below.

➢ The reductive amination route

![Chemical reaction diagram]

Figure II.1.2.1.2.1: The reductive amination route for the synthesis of MDMA.

In the Netherlands, the method most frequently used to prepare MDMA is the low-pressure reductive amination route of the ketone at slightly elevated temperature [Poortman, 1998]. As shown in the second reaction, safrole is a possible precursor for the synthesis of 3,4-(methylenedioxy)phenyl-2-propanone most commonly used as direct precursor.
The Leuckart reaction

\[
\begin{align*}
\text{N-Methylformamide} + \text{HCOOH} & \xrightarrow{\Delta} \text{N-Methyl-N-formyl-MDA} \\
& \xrightarrow{\Delta} \text{MDMA}
\end{align*}
\]

3,4-(Methylenedioxy)phenyl-2-propanone

Figure II.1.2.1.2.2.: The Leuckart reaction for the synthesis of MDMA.

Contrary to the production of amphetamine, this reaction is rarely used for the synthesis of MDMA.

The nitropropene route

\[
\begin{align*}
\text{Nitroethane} + \text{H} & \xrightarrow{\Delta, \text{Base}} \text{3,4-Methylenedioxyphenyl-2-nitropropene} \\
& \xrightarrow{\text{LiAlH}_4} \text{MDA}
\end{align*}
\]

3,4-(Methylenedioxy)piperonal

Figure II.1.2.1.2.3.: The nitropropene route for the synthesis of MDA.

This is the condensation reaction between nitroethane and piperonal, also commonly used for the synthesis of other amphetamine derivatives.
The bromopropane route

![Chemical Structure](image)

**Figure II.1.2.1.2.4.** The bromopropane route and the synthesis of 3,4-methylenedioxy-P-2-P.

The reaction of safrole (obtained by extraction from sassafras oil or steam distillation from sassafras plant material) with hydrobromic acid to 2-bromosafrole is an alternative method to the use of 3,4-(methylenedioxy)phenyl-2-propanone (a controlled precursor).

II.1.3.2. **Production of tablets**

Compressing powder or granules into a tablet is one of the simplest ways of forming a product immediately recognisable by people. Tablets are the form of prescription drugs and other remedies most often found in the pharmaceutical industry, because they make transportation and storage easier, are an ideal way to measure and ensure correct dosage of active substances, and are quite pleasant for intake.

The name of “tablet” has its origin in the Latin word “tabuletta”, meaning a little bar. In the pharmacopoeia [Ph. Helv. 8, 1997] the Latin term “compressus” is used, which derives from the Latin verb “comprimere” and means to compress or press together. Therefore, behind the term “tablet” one finds, not so much the definition of a particular appearance but the result of a production process, i.e. the result of powder or granulate compression. Physically, a tablet is defined as a disperse system of solid and gas phases with relative volumes which highly depend on the degree of compression.

Pills can have forms similar to tablets, but by definition are not the result of a compression. Rather, a paste is pressed or formed into a mould, and pills are then produced by cutting out or by punching the moulded paste, which may be of variable composition [Bauer et al., 1993].

II.1.3.2.1. **Mixtures of powder and granules for tablets**

The composition of tablets can be very complex, and formulations can vary considerably in ingredients from one manufacturer to another. Depending on the final uses and on the chemical and physical properties of every active substance, an accurate and individual selection of suitable ingredients and proportions is necessary in order to get high-quality tablets. In fact, the powders or granules used to produce tablets are made by mixing the active ingredient with a combination of excipients. In forensic science, excipients often are also known as cutting agents.
Depending on their expected behaviour and properties, excipients can be divided into the following different groups of substances:

- **Diluents**: Pharmacologically nonactive, inert substances needed to fill up and increase the volume of the tablet or to disperse more perfectly a mixture of active substances.
- **Binders**: Binding agents are added to an initial mixture to produce adhesive solutions. Distinction is made between binding agents for wet and dry granulation.
- **Disintegrators**: Substances which in water at low temperatures are insoluble but will swell; these are used for diffusion control in the body of the tablet and to produce disintegration of the tablet in water.
- **Lubricants**: In the tablet machine, lubricating agents improve the sliding properties of the powdered and granulated materials used.
- **Damping agents**: Added to powder or granules when these tend to dry and would thus hamper tablet production.
- **Drying agents**: Used to incorporate liquid starting materials or to avoid the liquefaction of production powder or granules.

Indications concerning standard and high-quality mixtures of excipients for particular and general preparations are reported in the national pharmacopoeias, which are the basic regulatory manuals of chemists. Examples of the most common excipients used in pharmaceutical industry are given below.

<table>
<thead>
<tr>
<th>Excipients</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluents</td>
<td>Lactose, cellulose, mannitol, starch, glucose, calcium, phosphate, talc</td>
</tr>
<tr>
<td>Binders</td>
<td>Gelatine, polyvinylpyrrolidone, cellulose ether and powder, sucrose, mannitol, starch</td>
</tr>
<tr>
<td>Disintegrators</td>
<td>Different types of starch and starch derivatives, polyvinylpyrrolidone, sodium carboxymethylcellulose</td>
</tr>
<tr>
<td>Lubricants</td>
<td>Salicylic acid, stearic acid, magnesium stearate</td>
</tr>
<tr>
<td>Damping agents</td>
<td>Glycerol, sorbitol</td>
</tr>
<tr>
<td>Drying agent</td>
<td>Salicylic acid</td>
</tr>
</tbody>
</table>

Table II.1.2.1.1.: Examples of employed excipients.

In addition to the major active ingredients, additional active substances commonly called **adulterants** in forensic science, such as caffeine, ephedrine, paracetamol, procaine,
lignocaine, 1-phenylethylamine may be added to the illegal products. Other products such as dyes, aromas and sweeteners may be used to give particular properties and qualities to the tablets [King, 1997][Goldmann, 2000].

A mixture can be prepared in different ways prior to compression. If the mixture has good sliding properties, optimal elasticity, and no tendency toward a mechanical separation of the components, a direct compression of powder may be considered. It is the most economical way of production, but also the most difficult path to produce high-quality tablets.

Granulation of powders is the other possibility for preparing the tabletting mixtures. One can distinguish dry granulation, especially for humidity-sensitive substances, and damp granulation. Damp granulation of mixtures is the easiest and least complicated process for getting material for compression purposes. Most industrial applications use this last method for the production of large quantities of tablets.

II.1.3.2.2. Compression and pressures

Once the mixture is prepared it is ready for the tablet press, where the tablets are compressed between two punches in a die. Punches and dies, which are contained within the turret of the machine, are high-quality products precision engineered to 1/100 mm. Care has to be taken when handling such a tool.

Even if more and more complex machines are used, the basic principle of the tabletting cycle remains the same. It consists of three phases:

I. **Filling** The amount of granules or powder is weighed, and the exact granule or powder volume is fed into the die bore.

II. **Compression** Pressure is applied to form the granules into a solid body. Sometimes the tablet is pre-compressed in order to remove all air at reduced pressure. This allows production to proceed at a much higher speed.
III. Ejection

The final stage is removal of the tablet in preparation for the next tablet to be formed. The lower punch pushes the tablet out of the die. The entire process then starts again and continues until the desired number of tablets is produced.

Generally two different types of presses are described in the literature [Tillson and Johnson, 1974][Bauer et al., 1993].

![Figure II.1.2.2.2.2.]: Schema of the pressing sequence of a single-station machine [Kummer, 1998].

The simplest type of tablet machine is the **single-station machine**. Pressing force is given to the upper, mobile punch by an eccentric arm. The lower punch is fixed during the compressing phase and only moves to eject the new tablet. Single-station machines usually have one or two pairs of punches. The die and supporting table are fixed. Production efficiency of this machine is up to 3000 tablets per hour.

![Figure II.1.2.2.2.3.]: Schema of the pressing sequence of a rotary press [Kummer, 1998].
Large quantities of tablets are produced by **rotary presses** with 8, 16 or more pairs of punches. The punch pairs are contained in a rotating turret. Normally, one complete rotation gives one tablet per punch pair. Contrary to single-station machines, both the upper and lower punch is moving during the compression phase. Production efficiency of rotary presses is above 10,000 tablets per hour and can reach 1 million tablets per hour, depending on the number of punches, rotation velocity, and especially the “feeding” capacity. “Feeding” capacity often is the limiting factor.

### II.1.3.2.3. Problems in tablet production

The most current manufacturing problems can be described as follows.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient mechanical strength</td>
<td>● low pressure</td>
</tr>
<tr>
<td></td>
<td>● unsuitable or insufficient binding agent</td>
</tr>
<tr>
<td></td>
<td>● excess starch</td>
</tr>
<tr>
<td></td>
<td>● excess lubricating agent</td>
</tr>
<tr>
<td></td>
<td>● overly dry mixture unsuitable for tablet pressing</td>
</tr>
<tr>
<td>Decomposition of the tablet into layers</td>
<td>● insufficiently moist mixture</td>
</tr>
<tr>
<td></td>
<td>● air inclusions</td>
</tr>
<tr>
<td></td>
<td>● mixture insufficiently deformable</td>
</tr>
<tr>
<td>Sticking of mixture to punches and die walls</td>
<td>● not enough lubricating agent</td>
</tr>
<tr>
<td></td>
<td>● excess moisture in the mixture</td>
</tr>
<tr>
<td></td>
<td>● lowering of point of fusion by mixture</td>
</tr>
<tr>
<td>Unsuitable disintegrating time</td>
<td>● unsuitable disintegrator</td>
</tr>
<tr>
<td></td>
<td>● overly hydrophobic excipients</td>
</tr>
<tr>
<td></td>
<td>● not enough drying agent</td>
</tr>
<tr>
<td></td>
<td>● excessive porosity (excessive pressure)</td>
</tr>
<tr>
<td>Fluctuations in dosage</td>
<td>● insufficient flowability (sliding) of mixture</td>
</tr>
</tbody>
</table>

Table II.1.2.3.1.: Some problems in tablets and their causes.
II.1.4. Characterisation and analysis of ecstasy tablets

II.1.4.1. Visual and physical description

The description of a sample is the natural and instinctive first step in case work. In fact, physical and visual analysis of illicit drug preparations is largely limited to tablets and capsules. In the medical domain, sample description of prescription drugs and remedies is used to identify products. To this end, lists and tables have been created to facilitate an identification [Identa, 2002]. On the other hand, it appears that the use of morphological and visual description is almost inexistent in the investigative process. Literature on the description of drug samples is rarely available, and its use as a support for drug intelligence has rarely been discussed in publications.

There have been few attempts at a systematic collection of particular physical or visual data, as for example the logo project of EUROPOL [EUROPOL, 1997][EUROPOL, 2000] in which imprints and designs on ecstasy tablets were simply codified by numbers. Such information is not available in “real time”, and thus is of little or no use in investigations unless it can be combined with other forensic characteristics of ecstasy tablets. In the literature, no indications have been published about the use of other features such as, for example, shape and colour or weight and diameter which could be employed for intelligence purposes. Such related problems as personal colour perception, description, and codification have been issues discussed in other forensic science domains [Massonnet, 1996][Thornton, 1997].

Few publications have described research results on a detailed physical comparison of tablets in forensic science. Some of these methods rely on techniques used in the ballistic identification of firearms. In fact, the expression “ballistic measures of tablets” is sometimes used in drug analysis, too. Other papers relate to toolmark identification.

The use of optical instruments (such as microscopes, comparative microscopes) for the determination of tablet shapes, for detailed measurements of physical dimensions, and especially for a comparison of damage marks of punches that are transferred to a tablet have been reported for “microdot” tablets of LSD and illegally produced pharmaceuticals [Gomm, 1975][Gomm et al., 1976] as well as for ecstasy tablets [Portmann, 1996]. A non-contact confocal-laser optical sensor has been reported as a tool for surface characterisation supplementing toolmark identification techniques [Katterwe et al., 1998].

In pharmacy, the quality standards are laid down in the Pharmacopoea [Ph. Helv. 8, 1997], not only for weight and diameter but also for other, less known characteristics such as the tablet disintegration time in water, the hardness and the friability. These features have not been applied to forensic science analysis, but in some reports these characteristics have been evaluated with respect to their forensic discriminating power [Kummer, 1998].

II.1.4.2. Chemical analysis of ecstasy tablets in forensic science

While the visual and physical analysis of ecstasy tablets appears to have been largely neglected in prior research, distinctly more work has been published on the chemical identification and quantification of illicit synthetic drugs [Maehly and Strömberg, 1981] (Annex 2: Selected analytical methods for the analysis of ecstasy tablets).
Various presumptive tests (also called spot tests) which are used to identify drug classes are known and available for amphetamine and its derivatives. The most common presumptive tests for amphetamine-like substances are the Marquis test, the sulphuric acid test, the Simon test and the gallic acid test [UN, 1995]. Doubtful presumptive tests (for example the E-Z test of SP@NK Products, Amsterdam) have appeared in rave parties; it has been claimed that they give specific reactions, both in colour and reaction time, depending on the active substance and its quantity. No scientific report has demonstrated the reliability of such tests.

As for the natural drugs: heroin and cocaine, an identification by crystal tests has been studied and reported for synthetic drugs [Petter, 1995].

Thin-layer chromatography (TLC) is the most economical and easy way of all separation techniques used for identification. Combined use of different chromatographic systems increases the discriminating power for the identification of substances. Fluorescent derivatives as well as certain colour reactions have been reported to enable a more detailed differentiation of amphetamine and its derivatives. A characterisation by formation of dansyl derivatives appears to be more effective on plates [Kala and Madej, 1997][van der Ark et al., 1978][Sinnema and Verweij, 1981].

Many analytical instrumental separation and identification methods have been treated and discussed in the forensic literature. Pure identification methods such as infrared spectroscopy (IR) [Skinner, 1990] or ultraviolet visible spectroscopy (UV-VIS) [Clark, 1984] or more powerful methods such as nuclear magnetic resonance (NMR) [Sinnema and Verweij, 1981] were employed to discover and characterise new and unknown substances.

Mass spectrometry (MS) has been used to characterise substances such as amphetamine or derivatives and their impurities; it is usually combined with chromatographic methods [Verweij, 1996][Noggle et al., 1991]. Chromatographic separation methods such as gas chromatography (GC) and high-pressure liquid chromatography (HPLC) [Lambrechts and Rasmussen, 1985] are widely described and used for identification and quantification in routine work. More recently, capillary zonal electrophoresis (CZE) [Esseiva et al., 1997][Sadeghipour et al., 1997][Bokor et al., 1997] as well as supercritical fluid chromatography [Mc Avoy et al., 1999] have been used to separate and quantify amphetamine and its derivatives. More sophisticated analytical procedures such as the chiral separation of amphetamines are sometimes described for CZE, HPLC and GC [Varesio and Veuthey, 1995][Makino et al., 1996].

The derivatisation of substances is often used to make them more volatile and stabilise them for analytical procedures. For example, sugars and similar organic products can be derivatised with N-methyl-N-trimethylsilyltrifluoroacetamide (MSTFA) for GC analysis [Guéniat et al., 1997][Guéniat, 2001]. Derivatisation procedures of secondary amines with pentafluoropropionic anhydride (PFPA) have been described to obtain the corresponding amides [Bovolenta and Morselli, 1997]. Other derivatisation agents such as R(+)–α-methoxy-α-(trifluoromethyl)phenylacetic acid (MTPA) can be used in GC to give diastereomeric derivatives [LeBelle et al., 1994].

The elementary composition of samples is rarely reported, and not used routinely. More common methods of analysis are ion-coupled plasma mass spectrometry (ICP-MS) and atomic absorption spectrometry (AAS) [Marumo et al., 1994] or energy-dispersive X-Ray spectrometry [Lomonte et al., 1976]. In a comparison of ICP-MS and ICP-AES (ion-coupled plasma atomic emission spectrometry), the differentiating power of such methods was demonstrated [Comment, 1998][Comment et al., 2001].
II.1.4.3. Profiling and sample comparison

II.1.4.3.1. Definitions

In forensic science drug analysis, the chemical characterisation of drug samples by detailed examination of organic components and traces is generally described as drug profiling, but this only yields a general classification. Differences must be made between the analysis of major and minor components (including diluents and adulterants) and the analysis of trace components. Normally, the following two definitions are proposed.

**Chemical composition (general profile)**

A general profile consists of the (mainly) organic profile or chromatogram of the drug sample. It gives indications about the type and quantity of the major and minor constituents, such as the active substance itself, the diluents and adulterants, cutting agents and major impurities.

**Trace profile (chemical signature)**

A trace profile is obtained by determining the relative amounts of minor components in a sample (often also improperly called impurities). Usually this is preceded by an extraction step. Sometimes this profile is also abusively called “the chemical fingerprint” of the sample [Huizer, 1994].

Both types of analysis yield valuable data for classifying, comparing and linking different drug seizures, but differ in their qualitative and quantitative information content.

The general profile of a sample can be compiled by the common separation methods described above. Little has been reported in forensic publications about the use of such information for intelligence purposes; King pointed out that profiling can indeed be used in this way [King et al., 1994]. One important effort in the operational implementation of impurity profiling data of amphetamine powder in drug intelligence is the Nordic Amphetamine Project [Alm, 1997]. This project started in the 1980s and has recently been tested in a feasibility study of the European Union.

Trace profiles have been much more popular, according to available publications, in the analysis and identification, both of synthetic and natural drugs. Impurity patterns of synthetic products are strongly influenced by a number of experimental conditions. These traces can be highly indicative.

Two main objectives are pursued by trace profiling [Strömberg and Maehly, 1979]:

A. A direct comparison of chemical signatures, in order to find links between different samples seized.

B. Conclusions as to the methods of synthesis of clandestinely prepared illegal substances.

In the domain of amphetamine and related substances, profiling experiments were first reported in the 1970s [Strömberg, 1975][Kram and Kruegel, 1977][van der Ark et al.,
1978][Lomonte et al., 1976], at the same time when such experiments were performed with natural drug samples.

Generally three main steps are involved in trace profiling:

1. Extraction of the impurities or traces.
2. Analysis and identification of trace products by instrumental methods.
3. Computer-assisted comparison of the trace profiles.

Apart from the organic traces, other traces are present in drugs. Thus, inorganic profiles of illicit drug samples also give valuable information. This type of analysis is independent of the organic analysis [Guéniat, 2001]. There has been one paper discussing the use of ICP-MS and AAS for the generation of inorganic or elemental profiles of methamphetamine samples in Japan [Marumo et al., 1994]. Between samples, large intra variations were observed.

For the purposes of batch-to-batch comparison, preliminary studies have been made on the use of natural isotope abundance ratios $^{13}$C/$^{12}$C and $^{15}$N/$^{14}$N in MDMA samples [Mas et al., 1995]. This approach appears quite promising.

II.1.4.3.2. Extraction of trace substances

Large samples are needed in order to detect and analyse trace components (in the range of ng/component). Trace components should first be extracted in such a way that the principal active substance is left behind in the initial solution, in order to avoid overloading the separation columns. In the literature, different extraction methods have been described depending on the type of impurities looked for [Sinnema and Verweij, 1981]. They can be divided as follows:

**Weak bases** A sample amount is diluted in water, the solution is acidified with tartaric acid and extracted with ether. The ether phase is re-extracted with an aqueous solution of 4 N HCl. A portion of the aqueous acid phase is made alkaline and extracted with chloroform [van der Ark et al., 1978].

**Neutral substances** Evaporation of the ether phase (concentration of diluted substances).

**Strong bases** The tartaric solution is made alkaline and extracted with chloroform.

A routinely adopted way of extraction is the dilution of about 200 – 500 mg of the sample in a phosphate buffer at pH 7 and liquid-liquid extraction in $n$-hexane [Bovolenta and Morselli, 1997], $n$-heptane [Strömberg et al., 1983], $n$-octane [Jonson and Strömberg, 1994], or dichloromethane [Lambrechts and Rasmussen, 1985]. Similarly, phosphate buffer solutions of pH 7 were made alkaline with 10 % Na$_2$CO$_3$ and extracted with ethyl acetate [Inoue et al., 1994], $n$-hexane [Tanaka et al., 1992], or $n$-octane [King et al., 1994].

Sometimes samples are diluted directly in water or basic solutions (for example 2 N NaOH or NH$_3$), then extracted into chloroform [Huizer et al., 1985][Noggle et al., 1991], methylene chloride and ether [Bokor et al., 1997], ethyl acetate [Sippola and Kärkkäinen, 1998], or toluene [Inoue et al., 1994]. Methods involving extraction in benzene should be avoided today because of the known health hazards [Lambrechts et al., 1984][Strömberg, 1975].
Simple dissolution in chloroform [Huizer et al., 1985] or methanol [Sippola and Kärkkäinen, 1998] is easy, but appears to have not often been used.

An interesting liquid-solid extraction method was proposed and successfully compared with the usual liquid-liquid extraction methods; it involved “Bond Elut” C-8 columns and subsequent acetonitrile desorption for a particular HPLC application [Lambrechts and Rasmussen, 1985]. In some publications solide-phase microextraction (SPME) was proposed as the method of choice [Rashed et al., 2000][Coubaros et al., 1999][SMT, 2003].

II.1.4.3.3. Instrumental analysis and identification

Chromatography is the method of choice when determining the trace profile of a drug sample, and nearly all publications in forensic science refer to the use of GC separations for this purpose. Often GC-MS methods are proposed for the formal identification of the type of impurity, and GC-FID methods are used for recording the trace profile of illegal drug samples. In fact, good selectivity and sensitivity are necessary. Good reproducibility has been achieved with samples of the same origin.

In the first published studies concerning amphetamine profiling, packed columns with nitrogen as a carrier gas and on-column injection were used [Strömberg, 1975][Sanger et al., 1979]. FID and ECD were used as the detectors in these experiments.

As soon as capillary columns were commercially and routinely available, they replaced the packed columns in almost all analytical applications of GC. The first ones had a length of 11 m (0.2 mm i.d.) and a methyl-phenyl-vinyl silicone rubber (SE-54) stationary phase [Strömberg et al., 1983]. In this case FID and NPD were examined as the detectors, and the injection was made in the split mode (∼1:40).

Most GC methods reported for the profiling of amphetamine [Jonson, 1994] and methamphetamine [Perkal et al., 1994] employ 25 m capillary columns with a nonpolar stationary film. In the publications cited, splitless-mode injection was chosen. FID are nearly always used as the detectors, and results are recorded with computerised data analysis stations. The use of an automatic sampler is highly advisable, especially in routine work. The use of longer capillary columns (50 m) has also been reported [Kärkkäinen et al., 1994]. In methamphetamine analysis, experiments were made using a 15 m wide-bore column (DB 1) [Inoue et al., 1994].

In the application of fast GC methods, little experience appears to have been published, except for some initial tests [Sippola and Kärkkäinen, 1998].

Apart from gas-chromatographic methods, impurities of illicit amphetamine samples have also been analysed by reversed-phase HPLC with UV detection, and their trace patterns have been used for comparison [Lambrechts and Rasmussen, 1985]. Reproducible retention times were obtained, but in practice, HPLC has rarely been applied.

It is quite astonishing that little work has been done on the identification of methylenedioxy-substituted amphetamine impurities such as MDMA, MDEA, and MDA [Verweij, 1992][Bohn et al., 1993]. Little information was found in the recent literature about profiling and comparative tests involving these types of drugs of abuse [Gimeno et al., 2002].
II.1.4.3.4. **Chemometry and computer-aided comparison**

The most efficient way so far of trace profile comparison is the visual comparison of chromatograms. Especially in case work for courts, the expert is personally estimating and interpreting the analytical results. Of course, this is highly time-consuming and implies a lack of overall view, and would therefore be quite inefficient for intelligence purposes. Following today's general trend, automation of at least part of this work was explored [Jonson, 1994][Casale and Watterson, 1993][Kärkkäinen et al., 1994]. The final aim is that of excluding pairs of profiles having different chemical signatures, and reporting those that may originate from the same batch. Their original profiles are then more closely examined by inspection.

Links at two different levels are mainly of interest: (i) samples that belong to the same manufacturing batch, and (ii) samples made by the same recipe or in the same laboratory, which is a higher general level of classification. These two levels of linkage are sometimes defined as **batch relation** (through sample comparison) and **source relation** (through sample classification) [Jonson and Strömberg, 1994].

As described before, GC-FID is the method of choice, particularly because of its sensitivity and selectivity. Traces can be detected and separated in an efficient and reliable way. The reproducibility of the results is good, but can deteriorate after long time intervals. The reproducibility is also a source of problems in the inter-laboratory comparison of chromatograms. Small variations in the resulting chromatograms occur as functions of many particular environmental and external factors. An attempt to standardise and unify GC analysis in order to get unique and constant results was made in a project on an international level [Strömberg, 1997]. It is very important to exactly know deviations that have a purely analytical origin, in order to be able to evaluate and interpret the inter and intra variations of impurity profiles of different illegal product seizures. These variations have been analysed with the aid of simulated and specially synthesised samples [Strömberg et al., 1983][Stead, 1991][Huizer, 1994][Jonson and Strömberg, 1994][SMT, 2003].

In GC analysis, the absolute and relative retention times can be used to identify the components in a sample mixture. The method of normalisation to an internal standard is commonly used in GC analysis and in forensic science [Pikkarainen, 1996]. Alkanes such as decane, hexadecane, eicosane and heneicosane are often reported as internal standards [Perkal et al., 1994]. Dimethylamine or diphenylamine have also been used [Kärkkäinen et al., 1994]. An internal standard is added to the sample at the beginning of the analytical procedure, but sometimes a relevant impurity component can also be chosen for selective normalisation. A rather complete statistical evaluation of reproducibility has been reported for the analysis of amphetamine samples in the Nordic countries [Pikkarainen, 1996]. Another study investigated more in detail the retention locking method [SMT, 2003].

For computerised comparison, the trace profiles usually are approximated by a selected number of characteristic peaks. Only the areas of these key sample components are then automatically compared. Different mathematical algorithms (chemometrical methods) or even more complex computer data mining methods (neural networks) have been studied and routinely applied as comparison functions.

A particular way of representing transformed impurity profiles are pictograms. Ignoring the main peaks, a number of minor impurities are chosen, the highest one of them is normalised to 100 % and all others are expressed as a percentage of the highest [Ensing et al., 1992].
The following comparison functions were found in the forensic literature:

- **The “Finnish method”: Retention Indexes (RI) and Similarity Indexes (SI)**

  [Kärkkäinen et al., 1994][Talka and Sippola, 1997]

  In the retention index method, the analyte peaks are identified on the basis of their retention times relative to different reference compounds. Thus, seven $n$-alkanes were added to the sample extract as reference compounds. Identification of the reference compounds is based on absolute retention times and on their abundance. To the standards, a retention index (RI) value of 100 times their carbon number is assigned. Retention indices for all other peaks are calculated as follows:

  \[
  RI(x) = 100z + 100 \cdot \frac{t_R(x) - t_R(z)}{t_R(z + 1) - t_R(z)}
  \]

  Peaks are identified according to their RI (± 0.3 % deviation), and relative peak areas are used for comparison. Impurities are normalised to a selected main impurity. The similarity index (SI) between two samples impurity profiles is then calculated in the following way:

  \[
  SI = \sum_{i=0}^{l} B \quad \text{where} \quad B = 100 \cdot \frac{k^i}{A}
  \]

  \[
  A = \left( \frac{\text{Area}(i)}{\text{Area}(j)} \cdot w - k^2 \right)^{k^i} - 1.0 + k^i
  \]

  For an assessment of the amphetamine profiling results, a statement based on a five-level scale of similarity is proposed (similar, same type, no conclusion, different type, and dissimilar), but often this is not a satisfactory answer.

- **The “Swedish method”, Part 1: The quotient method**

  [Jonson and Strömberg, 1993][Botti, 1999]

  This method is exclusively used for the comparison of samples on a batch level. Here the authors propose to use areas of $n$ selected impurity peaks found in an impurity profile of the amphetamine sample. Comparison is always made with two profiles.

  Profile X \quad x_1, x_2, x_3, \ldots, x_n
  Profile Y \quad y_1, y_2, y_3, \ldots, y_n \quad \text{where} \quad x_i \text{ and } y_i = \text{peak areas.}

  It is basic to this method to represent the peak area quotients calculated as:

  \[
  q_i = \frac{x_i}{y_i}
  \]
If the match of a pair of profiles is good, then the quotients cluster around some value that generally is not far from unity. The \( n-1 \) distances \( r_{ik} \) for all pairs of quotients are then calculated according to

\[
r_{ik} = \left| \frac{q_i - q_k}{q_i + q_k} \right|
\]

This formula yields a symmetric diagonal matrix with zero values on the diagonals. For each matrix the number of quotients with \( r_{ik} < r_{\text{max}} \) is calculated, where \( r_{\text{max}} \) is a preset limiting value. The largest of these numbers is denoted \( N \), and the comparison between the two profiles is said to be \( N \) quotients within \( r_{\text{max}} \). If \( N \) is less than a preset \( N_{\text{min}} \), then the two profiles are concluded not to match. It is necessary, therefore, to choose \( r_{\text{max}} \) and \( N_{\text{min}} \) properly.

The use of quotients of corresponding peak areas serves to eliminate the variation of profile intensity. By choosing the proper values of \( r_{\text{max}} \) and \( N_{\text{min}} \), the random variation in peak areas and the problems due to some strongly deviating peak areas are overcome. The method tolerates a preset number of strongly deviating quotients, so that false exclusion due to integration errors, peak contamination or interference from additives can be avoided. Since the calculations work with absolute peak areas, normalising is not needed. Distances \( (r_{ik}) \) are symmetrical; therefore it does not matter whether profile X is compared with profile Y or vice versa.

**The “Swedish method”, Part 2: Use of principal components (SIMCA)**

[Jonson, 1994][Jonson and Strömberg, 1994]

This method was developed specifically for the classification of samples on a level higher than the batch level. In this case the integrated peak areas of the impurity profile are the variables used to calculate a reduced number of so-called principal components (PC); these are linear combinations of peak areas. Often more than two or three PC are calculated, each of them orthogonal to the others. Each profile is then represented by a dot on the screen in a representation of up to 3D. Dots close to each other are likely to be related to the same class of samples (clusters of dots). The reduction of variables implies a reduction of available information, and therefore it is imperative to test the best linear combination of variables to appropriately describe a class of samples. By repeating these steps in an iterative manner a new accurate model for the description of a new class may be obtained [Botti, 1999].

Whether a class of samples is good or bad can only be judged by the user, but if a sufficient number of objects is available, the classification can be reconfirmed by arbitrarily dividing the objects into two groups and making a new classification of each group while following a different method.

A comparative study of the visual and computerised (SIMCA) classification has been described [Jonson and Strömberg, 1994], and has revealed some disagreement. However, when the two types of information are combined, the conclusions become much more useful. This situation, by the way, demonstrates a general difficulty encountered when applying clustering techniques while the number of classes is not known beforehand.

The calculations of discriminating power and of class distances according to the SIMCA manual are described elsewhere [Jonson and Strömberg, 1994][Botti, 1999].
The “Australian method”: The canonical variate analysis

[Perkal et al., 1994]

To avoid minor variations in instrumental conditions, trace profiles were standardised so that they could be directly compared. This was achieved by adding two reference standards to a sample and adjusting the profile according to the following equation:

\[ t = at' + b \]

where

- \( t \) = standardised retention time
- \( t' \) = measured retention time

\[ a = \frac{t_1 - t_2}{t_1' - t_2'} \]

and

\[ b = t_2 - at_2' \]

In this case \( t_1 \) and \( t_2 \) are the nominal retention times of the first and second reference standards, while \( t_1' \) and \( t_2' \) are the measured retention times.

Matched peaks are selected in the profile (while disregarding those of the standards), and are then normalised to the sum of the total selected peak areas:

\[ x_j = \frac{x'_j}{\sum_{i} x'_i} \]

where

- \( x \) = peak areas

In the determination of batch origin, three different criteria are used to compare two different drug samples:

1. The number of matched peaks

Retention times of two profiles are compared and a quotient \( q \) is calculated.

\[ q = \frac{2n}{N_1 + N_2} \]

where

- \( n \) = number of matched peaks in the two profiles
- \( N_1 \) and \( N_2 \) = total number of peaks

2. The area deviation of matched peaks (the Canberra index)

Only the areas of matched peaks are normalised so that the total area of matched peaks in each profile is unity. The deviation of the areas is then calculated as

\[ r_i = \frac{|x_i - y_i|}{x_i + y_i} \]

where

- \( x \) and \( y \) = normalised peak areas

The mean area deviation \( r \) is calculated as follows:

\[ r = \frac{1}{n} \sum_{i} r_i \]

3. The Euclidean distance of characteristic peaks
Areas of the characteristic peaks which occur in a seized sample are normalised in such a way that the sum of the areas is unity and a Euclidean distance $d$ is calculated:

$$d = \sqrt{\sum_i (x_i - y_i)^2}$$

The Euclidean distance method was also adopted as a unique comparison function, after normalisation of 30 characteristic peaks with an internal standard, for the comparison of methamphetamine samples [Inoue et al., 1994].

A set of prepared samples was employed as a learning population to determine limits for the above given values. Two samples within the corresponding limits are then likely to belong to the same batch. The following limits were found:

$$q > 0.85 \quad r < 0.06 \quad d < 0.05$$

➢ **The “DEA method”: Neural networks for cocaine**

[Casale and Watterson, 1993]

This method was described for the comparison of cocaine impurity patterns, but seems to be very interesting and easily adaptable to synthetic drugs.

Neural networks were proposed more than forty years ago as a model of the human brain. Their attractiveness is related to their special abilities in the areas of pattern classification, robustness, and real-time performance. The multilayer perceptron model was used. The network consists of nodes and interconnecting arcs that form signal paths. Associated with the arcs are weights that are adjusted during training to enable the recognition of training set patterns and the classification of given, unknown exhibits. Multilayer perceptron training is accomplished by repeated application of training patterns and the use of the back-propagation training algorithm to adjust the weights and node biases.

Cocaine signatures (containing 16 quantified impurities) were acquired and standardised. The selection of the neural network training set was particularly critical. Excellent results of training set selection were achieved by randomly generated training patterns in the vicinity of reference exhibits. Neural networks were found to be distinctly superior to distance functions classification and classical statistical approaches as described before.

➢ **The “Swiss method”: Correlation coefficient using a square cosine function**

[Guéniat, 2002][Esseiva et al., 2003]

This method has been in use for quite a long time for the comparison of major impurities identified by GC in heroin samples. It is described as a robust, reliable, and simple method for routine use in profiling work.

The chemical profile of the samples is characterised by $n$ variables, which can be depicted as a vector in a space of $n$ dimensions. In the case of heroin samples six major impurities of heroin are used.
Vector $a = (a_1, a_2, a_3, \ldots, a_n)$
Vector $b = (b_1, b_2, b_3, \ldots, b_n)$  
where $a_i$ and $b_i$ = peak areas.

In order to estimate the closeness of the two vectors, the angle between them is calculated according to the scalar product of the two vectors

$$\vec{a} \cdot \vec{b} = |\vec{a}| \times |\vec{b}| \times \cos \theta$$

The $C$ correlation value between two chromatograms (vectors $a$ and $b$) is then calculated from the square of the cosine of the angle between the two vectors, and normalised to 100:

$$C = 100 \times \left[ \frac{(a_1b_1 + a_2b_2 + \ldots + a_nb_n)^2}{(a_1^2 + a_2^2 + \ldots + a_n^2) \times (b_1^2 + b_2^2 + \ldots + b_n^2)} \right]$$

The correlation value is a number without dimensions, auto-normalised and independent of the length of the vector representing the size of the sample. The cosine function is advantageous, as it allows the result of the calculation to be processed in an easy way and yields a single data value rather than a graphical representation. According to the authors, this method tempts one to define thresholds below which no link can be established between two samples. However, reality appears to be closer to a continuous model such as that of Bayes, which is preferred by Guéniat and Esseiva.

A very interesting evaluation of different comparison functions applied to HPLC results using normalisation of areas and retention times has been proposed in the pharmaceutical literature [Welsh et al., 1996]. Artificial neural networks (ANN), $K$ nearest neighbours (KNN) and soft independent modelling of class analogy (SIMCA) were the subject of this study, and were compared to visual human appreciation. Again, ANN were found to be superior to chemometric and statistical methods.

On a more general level, pattern recognition methods have sometimes been described [Derde and Massart, 1982][Kingston, 1992].

II.2. FORENSIC INTELLIGENCE

II.2.1. Introduction

While there are many similarities between general and drug-related inquiries, certain areas are unique in the investigation of illicit drug trafficking. Over time, this recognition led to the development of specific investigation procedures and to the creation of special units or even agencies such as the Drug Enforcement Administration (DEA) in the United States of America [Garza, 1986].
Apart from the fact that data collected during the investigation of a drug-dealing case are of a broad variety and greatly varying reliability, it is particularly important to realise that every single drug case is only part of a vast criminal network. More than in the investigation of other criminal events, it is important to situate every drug case in this highly complex network of drug production and trafficking and to elucidate its links and connections on a regional, national and international level.

Consequently, the fight against illegal drug trafficking is highly complex and requires an equally complex investigation management. The collaboration and coordinated action of the different participants is essential, even more so the correct and efficient management of a heterogeneous mass of information. In drug investigations, it is fundamental to recognise that the final aim is not limited to finding and arresting criminal actors but implies fighting against a complex market.

In Switzerland today, the traffic of drugs is one of the most apparent and extensive examples of criminal organisations. An enormous amount of drugs is produced and sold every year, and the traffic involves a considerable number of illegally active people: drug producers, drug manufacturers, traffic-coordinating people, drug smugglers, money launderers, drug dealers and, last but not least, the many anonymous or known drug consumers. Not all of these network participants are at the same level of importance, but all of them belong to the same business network, and are therefore potential contributors of information about the organisation and its mechanisms. Often legal businesses, financial channels and even political channels are misused or built up by the criminal organisations themselves. The perception of legality and illegality is not always evident, and a global view covering legal and illegal activities is of fundamental interest in efforts to measure the real extent of the criminal activity.

Detailed knowledge of the structures, operating methods, and mechanisms of these organisations is the basis of efficient actions against this market. Efficient data management is necessary to extract such knowledge from the data.

**II.2.2. The principle of intelligence**

Every criminal investigation is based on the analysis of available police information; therefore, one fundamental part of this work is the disclosure and individualisation of links between people, objects, and criminal events [Ribaux, 1997]. The interpretation of these links on different levels can provide valuable information about criminal organisations, methods, and illegal trafficking. This is the basis of intelligence, which can be defined as follows.

‘L’analyse criminelle consiste en la recherche et la mise en évidence méthodique de relations d’une part entre des données de criminalité elles-mêmes et, d’autre part entre des données de criminalité et d’autres données significatives possibles, à des fins de pratiques judiciaires et policières’ [George, 1996][INTERPOL, 1997].

Criminal analysis thus is the product of systematic gathering, evaluation, and synthesis of raw data on individuals, objects, or activities suspected of being, or known to be, part of a criminal network.

The results obtained in the overall process of intelligence work yield new insights and knowledge concerning the criminal network studied. This new information itself sometimes is called “intelligence”.

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*Christian Zingg, IPS Lausanne*
Sometimes the notions of data, information, and intelligence are used in an undifferentiated way. But in criminal analysis, these terms are not equivalent. Data are the raw “material”. According to the particular circumstances, some of these data become pertinent, and are therefore transformed into information. The processing of and reasoning about this information produces actual, practically useful intelligence [Ribaux, 2003]. This last step is actually called the analysis part.

Being more than just the transmission of information (which matches the German term of “Meldewesen”), intelligence is defined as the end product of a complex procedure, “sometimes physical and always intellectual” [Meywirth, 1998][Godfrey and Harris, 1971].

II.2.2.1. The intelligence process

In the specific literature, the study of criminal analysis as a fundamental activity in investigations is mainly process-oriented. This has come about as the result of economy management doctrine. Historically, the conceptual description of intelligence has been developed in particular in the USA and in the UK at the beginning of the 1970s [Godfrey and Harris, 1971].

It is the aim of process-oriented description of intelligence to define simple procedures, to optimise organisational structures, and to formalise the application of collection and analysis methods. This is a difficult task, as a conflict often arises between generalisation and detailed specification. An overly general process definition may be valid over a wide range of activities, but has little concrete use. An overly detailed process description, on the other hand, probably is highly efficient in its application to one particular problem, but probably quite useless in other application domains. In fact, an inappropriate application of processes has often been a reason for poor understanding and unsatisfactory results. This has often been aggravated by definitions of terms and methodologies that are confuse and imprecise.

The following example description of the intelligence process [Godfrey and Harris, 1971] summarises the main points of the process, its advantages, and its limits.

- **Intelligence Process**
  1. **Planning Phase.** Planning of collection methods according to questions like who, when, …., what has to be collected.
  2. **Collection of data.** Application of various collecting methods.
  3. **Collation of data.** Structured combination and structured storage of data.
  4. **Evaluation.** Assessment of the exactitude of the information source and the quality of data.
  6. **Synthesis.** Derivation of conclusions as a basis for new operations.
  7. **Recommendations.** Generation of new operational and strategic measures.
  8. **Dissemination** of analysis results and of any valuable material extracted.
  9. **Evaluation.** Appraisal of the extent of activities touched by the operations.
As in this example, all process descriptions refer to linear procedures. The interconnection of different phases is sometimes mentioned, but often insufficiently described as part of the analysis method. The dynamic dimension of an intelligence process is often ignored, or only partly described [INTERPOL, 1997]. It is intuitively evident that every analysis procedure creates new questions, which implies the beginning of a new process, or rather of a circular, never-ending iterative process. Various processes have been discussed and compared with other process models, as for example the German one [Meywirth, 1998].

Intelligence is a process that should consist of a series of interconnected functions or activities, but fundamentally it is the result of a two-step process: the collection of data and the analysis and interpretation of accumulated information [Ribaux, 1997]. Both steps are highly correlated, and thus yield an iterative intelligence process [Ribaux and Margot, 1999].

II.2.2.2. The first step: collection of data

The first step of the process is the collection of data, which is here subdivided in four sequential functions (points 1 to 4 above): planning of collection, the collection of data itself, the collation, and the evaluation of information.

To be efficient, collection of data must be focused. The collection methods must be evaluated according to certain questions and coordinated in order to avoid duplication of efforts. These questions may be: are data available and in what form, and if not, how can they be obtained in an efficient way? The original plans for the collection should be reviewed at different stages during the investigation. For the collection of data, often the availability of time is a crucial element.

Once the data are obtained, their collation is more than the simple saving of the material in files. Collation can be considered as a preparation or a “translation” of data into a structured organisation (for example a database). It includes the arrangement of collected material and the sifting of useless or incorrect information in order to prepare for the evaluation of collected data, that is, a judgement about quality and validity of the information. In the majority of cases, a systematic and coherent approach is necessary for the classification of information.

In this example, the collection of data has already been described in detail by subdividing it into four phases or functions. Even if their necessity is evident, priorities and sequences are subject to changes, depending on the domain treated.

II.2.2.3. The second step: analysis of data

The second main step in the intelligence process is the analysis and interpretation of prepared information. Rightly, this step is often emphasised as the heart of intelligence, since “…without the analysis function, a piece of information in the files remains just that” [Godfrey and Harris, 1971]. In the process example, the analysis step is divided into two functions (points 5 and 6 above), the actual analysis step and the synthesis of deduced knowledge.

The analysis function assembles bits and pieces of information and puts them together in such a manner as to show logical patterns and meaning. This phase is particularly dependent on the final goal of the intelligence work [Ribaux, 1997]. The precise formulation of the questions and hypotheses is of fundamental importance. The hypotheses are then tested, to be
adapted and re-evaluated as a function of new results acquired. Sometimes further collection
efforts must be awaited. Thus, this is a highly dynamic procedure.

When focusing on the expected use of final intelligence products, it is possible to
distinguish two categories of intelligence, which sometimes overlap [Perillo et al., 1994]:

> **Strategic intelligence**

Strategic intelligence refers to a macrolevel of organised crime
activity. It assists investigators in probing major criminal operations
and produces an estimate of future major criminal activity. It gives,
for example, a general overview of the illicit drug market and
statistical information on the actual business situation of it. No less
important is the extractable information on trends and long-term
changes, which can be used, not only in enquiring activity but also in
public information and prevention. Finally, strategic intelligence is
an input to the chief of the services and to his planning for more
effective action against crime.

> **Tactical (or operational) intelligence**

Tactical or operational intelligence refers to a microlevel. It aims at
establishing direct links between single cases or affairs. It mainly
concerns short-term investigations, and often ends with immediate
and concrete actions of intervention. In its simplest form, it supports
the supply of answers to requests from enforcement investigators for
information on specific subjects. It has a direct link to current
investigations.

Sometimes a slight difference is made between operational and tactical analysis. The
operational analysis is then described as the elucidation of phenomena of criminality
restricted to a particular time period, whereas tactical analysis is defined as strictly relating to
one or a restricted number of cases where intelligence may directly influence the inquiry.
This differentiation is rather fine, and in many cases not really necessary.

Independently of the intelligence type needed, various analysis techniques and methods
must be employed. These methods are most often the result of practical experience, and must
be recovered from the literature as case reports or descriptions of particular cases [Atkin,
1999].

Definitions of methodologies and methods are rarely reported in the literature, but some
results have been reported in this direction in studies on burglary evidence in connexion with
geographical and temporal analysis methods [Ribaux and Margot, 1999][Santtila et al.,
2003]. Some other methods of analysis applicable to particular domains of inquiry, but all
overly general, have been proposed in the literature and were summarised by Meywirth
[Meywirth, 1998]:

- **Association Analysis or Network Analysis** (Relations and links between people and
  organisations).

- **Telephone Record Analysis** (Data coming from phone tapping).

- **Event Flow and Activity Flow Analysis** (Chronological investigation of events and
  activities).
● Commodity Flow and Visual Investigative Analysis (Visualisation of trade and article fluxes).

● Financial Analysis (Bank and corporate records, analysis of financial situations and traffic)

● Crime Pattern Analysis and Time Series Analysis (Criminological observation of limited geographical or other victim-related zones)

● Threat Analysis and Vulnerability Analysis (Investigation of potential victims of dangerous criminal activities)

All points listed above refer more particularly to so-called “police data” (interrogations, phone records, and the like). Astonishingly, data of a forensic nature useful for intelligence analysis are almost completely absent. Attempts to apply intelligence methods of analysis to forensic drug information are nearly inexistent and have only been described in a fragmentary way [Perillo et al., 1994][Ribaux and Margot, 1999][Stead, 1991].

The importance of a proper synthesis of knowledge is often underestimated and ignored. A positive result can only be reached in an intelligence process when operational or strategic decisions are materialised. Therefore, intelligence reports must be unambiguous and customer-oriented. The type of intelligence report to be forwarded is highly dependent on the end user. They may be prepared in written or oral form, and they may be quite brief or quite complex documents. In this context, the analyst-investigator relationship has to be emphasised.

The last three points (7 to 9) in the proposed example of an intelligence process are more particularly concerned with the structured organisation of the investigative operations. This is actually a basic foundation for operational application of new intelligence knowledge.

II.2.3. **Forensic data and intelligence**

Data used for general intelligence purposes are of a broad variety, and come from different sources. The reliability of the data and the source of the data are a major concern for the analysts. Sometimes collected data are of a very weak nature (suspicions, observations, and the like), sometimes they are of much higher value (phone tapping, interceptions, etc.). The questioning of persons (a suspect, a witness, etc.) still remains the most common strategy for information gathering by police services [Kroll and Schwarz, 2001].

In forensic science, in analogy to the criminal intelligence principles, the data are represented by traces. As far as the traces become pertinent to the case or phenomenon treated, they change into material evidence (the information). The interpretation of this material evidence provides intelligence results for multiple practical uses [Ribaux, 2003].

The integration of forensic data for intelligence purposes by police services is still fragmentary, and to some extent ignored. Knowledge about the object of the crime itself, and particularly the information it carries, is still poorly understood and not always easy to interpret [Weijenburg, 1997].

Nevertheless, some restricted applications where forensic data have been collected and integrated more or less successfully into the intelligence process have appeared in recent years. In serial burglaries, practical examples have been shown on an operational and tactical level with the collection of tool traces, and particularly with the comparison of modus
other examples have been described where shoeprints [Girod, 2002], DNA [Peter et al., 2002], fingerprints, or drug samples [Esseiva et al., 2003][Zingg and Bovens, 2000] were used.

Forensic intelligence is essentially initiated with databases. Historically, one of the first applications in this sense was the Bertillons’ system of anthropometric data to identify recidivists. The systematic classification of other traces (such as fingerprints) has increased with the possibility of creating and analysing databases by computer. The information that can be extracted largely depends on the form of the database. Four different families (basic forms) of databases were described [Ribaux, 2003]:

**Form I: from the trace to the source.** Starting with a trace it is possible to find a source. A typical example is the identification of a person by comparing a fingerprint with a central database of fingerprints of recidivists (for example AFIS in Switzerland). An analogical example is the comparison of a DNA profile with a database in order to find personal data of a possible source. Also, the identification of a shoe as source for a shoeprint by database comparison belongs to this family of databases.

**Form II: from the source to the trace.** Another frequent form of database use is the search for corresponding traces when a suspected source has been found. Examples are the fingerprint of a possible burglar, the shoeprint of an arrested suspected burglar and so on. This is the inverse of Form I of the database family.

**Form III: the linking database.** In this case, traces with a common source are searched within the data collection in order to reveal links between different cases or, in the instance of drug cases, between seizures. DNA databases are often used in this way.

**Form IV: from the trace to the type of source.** In this case, the comparison of the trace with the data collection does not yield a unequivocal source but, rather, a type of source. Beginning from a collected projectile, for instance, this form of database would point to possible types of firearms, or paint traces would suggest possible types of cars.

None of these four basic forms of database will make it possible to associate the traces directly with a crime, and even less a person with a criminal act. It is necessary, therefore, to take into account the more complex combinations of traces and other elements of the criminal acts. The above four forms do provide a basic point of departure for interpreting the cases.

It is important to point out, finally, that in the forensic intelligence process the analysis step describes the interpretation of links. This must not be confused with the interpretation of the traces themselves according to a particular crime activity. In this further step, the evaluation of the traces is made in order to give a judicial report indicating the value and the coherence of the traces depending on different hypotheses. In this context, the Bayesian methodology is increasingly adopted as an effective method for analysing, criticising and checking the coherence of opinions in a given criminal action [Taroni et al., 2001][Robertson and Vignaux, 1995].
II.2.4. **Analysis of drugs and intelligence**

II.2.4.1. **Drug analysis in the Swiss judicial system**

Contrary to the Northern European countries where police is responsible for the main part of the investigation, in Switzerland as well as in the other central and the southern European countries the entire investigation is directed mainly by magistrates. The police in some way represents the operational arm of the investigating judges, who have the responsibility and decision power of a case.

Therefore, forensic science and particularly forensic drug analysis has developed in Switzerland according to the judicial requirements and necessities. Thus, because of the federal system, a multitude of laboratories including institutes of legal medicine, other state laboratories (such as cantonal laboratories), and even some private paramedical laboratories are in charge of the analysis of seized drugs.

The historical and standard role of forensic drug analysis was, and still is, that of providing evidence for court proceedings and of determining whether or not seized materials contain controlled drugs [Sanger et al., 1979][Stead, 1992]. Often a more detailed analysis of drug samples is required in order to quantify the active substance content and the presence or absence of any kind of cutting agents. In Switzerland, quantification of controlled drugs is frequently required by courts as a factor determining the penalty of a case. In fact, a decision of the Federal Court in Lausanne (ATF 109 IV 143) defines limits for “serious” cases (“cas graves”) according to the actual amount of the illegal drug. Propositions have been worked out to qualify penalty according to kind, total weight and purity of seized drug exhibits, in order to unify and standardise court decisions and punishment [Hansjakob, 1996].

<table>
<thead>
<tr>
<th>Pure substance</th>
<th>Quantity</th>
<th>Decision</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diacetylmorphine (heroin)</td>
<td>12 g</td>
<td>ATF 109 IV 143</td>
<td>1983</td>
</tr>
<tr>
<td>Cocaine</td>
<td>18 g</td>
<td>ATF 109 IV 143</td>
<td>1983</td>
</tr>
<tr>
<td>Total hashish (cannabis)</td>
<td>-</td>
<td>ATF 117 IV 314</td>
<td>1991</td>
</tr>
<tr>
<td>Amphetamine</td>
<td>36 g</td>
<td>ATF 113 IV 32</td>
<td>1987</td>
</tr>
<tr>
<td>MDA, MDMA, MDEA, etc.</td>
<td>-</td>
<td>ATF 125 IV 91</td>
<td>1999</td>
</tr>
</tbody>
</table>

*Table II.2.4.1.1.: Limits for “serious” cases (“cas graves”) in Switzerland.*

This situation has led to the current state of drug investigation and drug intelligence involving hardly any knowledge or study of the object of the crime, viz., the drug exhibit itself.
II.2.4.2. Data for drug intelligence purposes

Drug characterisation results in particular can provide valuable information to help support operational and strategic police inquiries [Stead, 1991][Zingg and Bovens, 2000].

For drug intelligence, physical and chemical data about drug exhibits would typically be of a particularly high quality because of the following essential properties.

1. **Objectivity**: the information is not person-related like a statement. It exists and can be tested repeatedly with identical results.

2. **Stability**: the properties of drug exhibits do normally not change over time and/or space except through specific handling (circumstantial evidence).

3. **Reliability**: the interpretation of forensic characteristics of drugs gives information about traffic and production on a chemical and physical level.

4. **Occurrence in the market**: the drug exhibits are seized in a variety of amounts at all levels of the illegal network (from the producer via the dealer to the consumer).

These factors support in an extremely objective way the acquisition of more knowledge about drug networks, their organisation and working methods. Comparing these kinds of data with other, more traditional ones used in drug intelligence (phone tapping, observations, etc.) they clearly can serve as a source of reliable information.

Both in strategic and in operational intelligence work, it is possible to differentiate two separate information domains, one generally called the “source level”, which is concerned mainly by the identification process, and the “activity level”, which is looking at the way the traffic is organised [Cook et al., 1998].

On the source level, it is possible to get information about raw materials used for production, such as precursors and other chemicals. This could, for example, lead to a new action plan of investigations in the chemical trade market. Other interpretations of collected data can valorise links between seizures and suggest a clearly common source tabletting machine, or at least a common underground laboratory.

On the activity level, for instance, intelligence is expected to help determining the extent of imports, clarifying dealer-user networks, associating samples with geographical areas, establishing how long clandestine laboratories have been in operation, observing the influence of police operations on available drugs, and so on [King et al., 1994][Stead, 1992]. The presence of some of these characteristics could strengthen the plausibility of a synthetic route, an extraction method, or a particular compression procedure for tablets, and so on.
II.2.4.3. The time factor

It seems important in conclusion to point out one additional fundamental factor making the difference between pure intelligence work and routine judicial drug analysis, viz., the time factor. Laboratories which are used to work for judicial purposes often consider this factor as a pure organisational problem.

Especially in operational actions, but also to some extent in strategic intelligence, the waiting time is a major concern. It is not only important to have a piece of information, but it is just as important to have it at the right time, and most desirably in real time. Relevant information at the wrong time may not only be useless but even detrimental to the efficiency of further actions.

This is also a fundamental factor for the success of forensic supported intelligence. The use of data collections and of computerised databases is fundamental, therefore. In drug analysis, the use of databases for comparison and intelligence purposes is rare, and has only summarily been described in the literature [Huizer, 1994]. Structured chemical and physical drug characteristics of selected cases as a starting population for primary comparison are not available for real-time intelligence support. The coherent collection of unambiguous, uncorrelated and formalised data is a basic necessity, therefore [Perkal et al., 1994].
III. MATERIALS AND METHODS

III.1. INTRODUCTION

During the first phase of this work various visual, physical, and chemical characteristics of ecstasy tablets have been measured and studied in order to investigate the potential of such knowledge in organizing the data for intelligence purposes. Most of the methods of characterisation have already been described in the literature; others were adapted to our needs. Some methods of analysis have been rejected without any tests for reasons such as excessive costs, particularities of handling, etc. Therefore, the methods discussed in this chapter represent a pertinent choice of published methods of analysis, and in some cases of adapted methods of characterisation, while methods not taken in consideration are described, in exceptional cases only.

The methods of analysis were evaluated according to the following properties:

1. Selectivity
2. Sensitivity
3. Reproducibility
4. Costs and simplicity

Particular emphasis was placed on the

5. Time factor (Rapidity)

The characteristics that have been selected and evaluated in order to gain a useful description of data on ecstasy tablets, are summarised in the following table. In a first phase, all seizures were systematically analysed following this scheme. The scheme has also been used as the basis for an existing and developing database that could be revised and modified to integrate new knowledge.

<table>
<thead>
<tr>
<th>Visual</th>
<th>Physical</th>
<th>Chemical</th>
<th>Seizure information</th>
<th>Admin. information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tablet shape code</td>
<td>Weight</td>
<td>Illegal substance</td>
<td>Date of seizure</td>
<td>Internal code</td>
</tr>
<tr>
<td>Imprint description</td>
<td>Diameter</td>
<td>Adulterants</td>
<td>Place of seizure</td>
<td>Date of intro-</td>
</tr>
<tr>
<td>Name</td>
<td>Thickness</td>
<td>Diluents</td>
<td>Reference number of</td>
<td>duction into the</td>
</tr>
<tr>
<td>Imprint code (EUROPOL)</td>
<td></td>
<td>Purity and content of</td>
<td>the case</td>
<td>database</td>
</tr>
<tr>
<td>Breakline</td>
<td></td>
<td>the illegal substance</td>
<td></td>
<td>Name of the</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
<td></td>
<td></td>
<td>operator</td>
</tr>
<tr>
<td>Photographs</td>
<td></td>
<td></td>
<td></td>
<td>Laboratory</td>
</tr>
<tr>
<td>Special marks</td>
<td></td>
<td></td>
<td></td>
<td>Total number of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tablets analysed</td>
</tr>
<tr>
<td>Other</td>
<td>Remarks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table III.1.1: Characteristics of ecstasy tablets selected in this project as systematic descriptors.
This data structure has largely been integrated into the ENFSI system for the transmission of data concerning ecstasy tablets [ENFSI, 2000].

For the present study, ecstasy tablets were sent to the laboratory mainly by mail. The police services did the sampling of the seizure at their offices. In a few cases the entire seizure was sent to the laboratory for sampling. For this reason data on wrappings and packaging were not integrated into the present research study, as they mainly were police minigrip bags. The tablets (in solid and in powder form) were kept separate by seizure, and were stored in a safe. The solutions prepared for analysis were destroyed after use.

In the following paragraphs, the methods of analysis of the various characteristics are described. Occasionally some indications about other methods or characteristics not pursued in the present work are provided.

### III.2. VISUAL CHARACTERISTICS

- **Imprint description, name and imprint code**

  Figures, signs, symbols, logos and letters are commonly used for the identification of trademarks. In tablet production, these appear as imprints. For practical use, it was decided to describe the imprints with three separate but highly correlated characteristics. These are treated together in this section.

  The imprints (on the front and backside) were first recorded in French to provide an imprint description. This description was a function of seizures previously codified. In fact, if the same imprint had already been found before, it was described with exactly the same words. It corresponds to the search in a predefined list of possibilities, which may be enlarged when necessary.

  In addition, the name was recorded in all known slang terms or other forms depending on the type of imprint. This included signs and symbols used by companies or other organisations. Examples are the letters WB for Warner Bros®, the letter M in a circle for Motorola®, or the Gemini sign for the Kappa® Company. This dual text description (imprint description versus name) allows the operator to be flexible in the recovery of imprints already codified at an earlier time.

  For easier classification and search possibilities, a codification of the imprints was introduced from the beginning. EUROPOL had already proposed some sort of imprint codes [EUROPOL, 1997], and this codification was adopted with the following limiting conditions. EUROPOL codes were introduced to describe only the imprint (logo), without taking into account colours or other characteristics of the tablets.

  The EUROPOL codification suffers from two shortcomings. First, it is a nonsystematic logo codification (a sequential number attributed to new tablets). For search purposes, codification in classes (for example, by animal, number, text, human figure, and company classes) would be more efficient. Second, new imprints are sometimes codified according to characteristics other than the imprint (their colours for example). Therefore, tablets having exactly the same imprint but different colours could have different numbers. On the other hand, using the EUROPOL codification was advantageous inasmuch as it pre-existed, and had been integrated into most international descriptors, which thus could be used as well.
Only in special cases, as for example with the letters WY found generically on tablets containing methamphetamine, a further internal codification was defined in the IPSC laboratory. This allowed different seizures of WY tablets to be distinguished.

In tablet shape evaluation, interesting information can be derived from calibrated photographs [Gobry and Zingg, 2000]. The computer-assisted recovery of imprints from calibrated photographs can help in the recovery of imprints already codified by different operators using different languages in different laboratories.

- **Breaklines**

  In the beginning, this characteristic was treated as a Boolean variable: presence or absence of a breakline. Two other, particular types of breakline were found and integrated into the list of choice. A limitation to the following choices was imposed.

  - No breakline
  - Yes, with a breakline
  - Yes, with a breakline and writing on the same side
  - Yes, with a particular breakline

  It is very straightforward to obtain information about scoring. This information does not include indications as to the form and the dimensions of the breakline.

  In previous work [Portmann, 1996], attempts had been made to measure breaklines micrometrically using typical ballistic analysis methods. Unfortunately, it was shown elsewhere [Kummer, 1998] that this method suffered from low reproducibility. It was also extremely time-consuming as a method providing a first classification. Moreover, no studies have been published until now which would demonstrate particular merits of such data in a comparative perspective.

- **Tablet shape code**

  The identification of tablets in the medical domain is facilitated by written lists and tables [Identa, 1993][Identa, 2002] or, in an interactive way, by Internet [Gelbe Liste, www]. All these approaches are generally based on the use of photographs, while the codification of the tablet’s shape is limited to a description of the form (round, oval, etc.). More details are provided by TICTAC [Tictac, www], which is a comprehensive CD-ROM database for the visual identification of tablets and capsules. In this case a wide selection of figures is given which describe the form of the tablets as well as their lateral appearance.

  Illegally produced ecstasy tablets happen to come in unconventional shapes and combinations of forms. It is possible, for example, to find the same lower punch in combination with two different upper punches. Therefore, there was a need for a more detailed, but still flexible way of describing the shape of illegal tablets. The following three-letter code was tested and selected as the most useful way.

  When describing a tablet’s shape, it must first be decided which is the front and backside of the tablet. This decision was made as a function of the following priorities, which were considered sequentially until a decision became possible. Once a decision had been reached, the remaining priorities were no longer important.
The priorities for the evaluation of front and backside of a tablet are as follows:

1. The breakline is always on the backside.
2. An imprint is on the frontside.
3. Numbers and letters are on the backside.
4. Other marks are on the frontside.

In those special cases when both sides of the tablet had a breakline or an imprint (number or letter), or when both sides are free of any marks but the surfaces are different, the alphabetical way of codification according to the list below was used.

The three-letter code was given according to the following table:

|  | In front |  | Frontside |  | Backside |
|---|---|---|---|---|
| R | Round | A | A | Convex |
| O | Octogonal | B | B | Flat |
| P | Pentagonal | C | C | Flat with rectangular rim |
| H | Hexagonal | D | D | Convex with rectangular rim |
| T | Triangular | E | E | Concave |
| G | Capsule | F | F | Ellipsoidal |
| A | Other | G | G | Round (Ball) |
| Z | Other | Z | Z | Other |

Table III.2.1: The three-letter system for the codification of the tablet shape.

An example is given below.

Table III.2.2: Example of a shape codification.

If this tablet had no imprint and no special mark, the final code in this example would have been RAB, according to the alphabetical order.
This three-letter code is a simple, flexible and very quick visual method, which until now has allowed all types of tablets to be codified. It is attributed on the basis of visual observations made by the operator, in special cases callipers were used in addition. When the surfaces of adjacent tablets only touched in the centre of the tablets, they were defined as being type-A tablets, but when they were touching at the sides they were defined as being type-B tablets. A larger number of code-possibilities has not been used on purpose in order to minimise false negative classifications when comparing different seizures.

The above method provides no information about the degree of convexity in the case of type A tablets. A few experiments were made to calculate the form of tablets by computer on the basis of calibrated photographs [Gobry and Zingg, 2000]. This method has not been further developed until now, but could be adopted, since it is not extending the measuring time much. In fact, it appears that a knowledge of the convexity factor would increase the discrimination between different seizures.

➢ **Colour**

(= alphabetical code)

This characteristic is a simple visual description, and was preferred over the more time-consuming chemical method of dye analysis. As colour perception heavily depends on the human eye, an entirely free description of colours would suffer from extreme variation. The proposed choice was a restricted list of colours. This choice of colours was made arbitrarily while referring to actual experience.

<table>
<thead>
<tr>
<th>White</th>
<th>Grey</th>
<th>Black</th>
<th>Orange</th>
<th>Pink</th>
<th>Red</th>
<th>Two-colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>Brown</td>
<td>Beige</td>
<td>Blue</td>
<td>Green</td>
<td>Yellow</td>
<td>Multicolour</td>
</tr>
</tbody>
</table>

*Table III.2.3.: List of the 14 “colours”.*

When necessary, the attributes of “light” or “dirty” could be added to this description.

➢ **Photographs**

(= multimedia x 3)

Photography, which is essential for the documentation of forensic material in general, was also necessary for the description of ecstasy tablets in the database. Photographs give an accurate and visible representation of the imprint and of the entire tablet. In this sense, the photograph is used to provide a controlled documentation of the tablets seized from which further data can be derived. Only one representative tablet of a given seizure (or of each variant) is photographed from the front, back, and side.

*Table III.2.4.: Example of photography.*
No ruler was introduced in the photograph, in order to minimise influences of reflected or scattered light. A standardised lighting and acquisition procedure guaranteed constant magnification of the tablet photographs.

The following apparatus was used for digital recording of the image.

<table>
<thead>
<tr>
<th>Optic</th>
<th>Macroscopic Leica Wild M420</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apozoom 1:6 (5,8-35x), with 0,5 front-lens attachment</td>
</tr>
<tr>
<td><strong>Illumination</strong></td>
<td>“Yoghurt” method</td>
</tr>
<tr>
<td><em>(see figure above)</em></td>
<td>Double liquid guide</td>
</tr>
<tr>
<td></td>
<td>Volpi Intralux 6000-1</td>
</tr>
<tr>
<td><strong>Image capture</strong></td>
<td>Colour video camera CCD (764x500 pixels)</td>
</tr>
<tr>
<td></td>
<td>Power Macintosh 8100/100AV</td>
</tr>
<tr>
<td></td>
<td>Video Apple soft</td>
</tr>
</tbody>
</table>

*Table III.2.5.: Description of the apparatus for the digital recording of the image.*

For increased speed of image capture, a workstation was installed in a fixed place. Tablets were illuminated through a yoghurt container as showed below, in order to diffuse light over the entire surface. This has since been developed into an annular lighting with standardised diffuse angular illumination.

*Figure III.2.1.: Apparatus used for the illumination of ecstasy tablets.*

The continuous technical development of digital cameras now provides better resolution and photographs of sufficiently high quality. Less time-consuming methods of illumination
were recently defined. In fact, the photographic part was the most time-consuming step in the visual characterisation of ecstasy tablets.

**Special marks**

Specific reproducible marks are rarely found on tablets, but when present they are highly indicative. To codify these marks, the method described by Portmann [Portmann, 1996] has been applied. In this method, a standard grid is placed over the photograph, so that the top and left-hand lines of the grid touched the top and left-hand sides of the tablet, respectively, as shown below.

![Grid](image)

**Figure III.2.2:** Example of codification for special marks.

A code description was then attributed according to the location of the special mark. In the example described here, it was B1 C1 D1.

Tablets without any imprint or with particularly symmetric symbols were placed so as to have the codified special marks at twelve o’clock.

### III.3. PHYSICAL CHARACTERISTICS

**Weight**

All weight measurements have been carried out by means of a calibrated Mettler® MT5 analytical balance. The precision of the measurements was ± 0.01 mg. Considering the high variation of tablet weights in given seizures, the precision needed could be reduced to one milligram.

**Diameter and thickness**

These measurements have been made with manual metallic callipers. The precision of these measurements was ± 0.02 mm. Digital callipers provide better reproducibility, especially when different operators are doing the measurements.

Thickness was always defined as the distance from the front to the back of the tablet. In the case of irregular forms, the measurements were taken in a sequence of decreasing thickness dimensions, as shown in the examples below (diameter 1, diameter 2, etc.).
Sometimes the diameter and thickness have also been determined directly from calibrated images of high quality, which revealed the potential of high-quality photography. These methods need to be further explored [Gobry and Zingg, 2000]. A prototype system is being set up based on these results [Margot, 2003].

### III.4. CHEMICAL CHARACTERISTICS

- **Illegal substance, adulterants and diluants**

  Gas chromatography has been chosen for organic chemical analysis of the tablet’s composition. The use of an MS detector for routine analysis was necessary, as ecstasy tablets are often of a higher degree of complexity in chemical composition than other drugs of abuse. In fact, the active substances cover quite a large variety of synthetic drugs, and it is not rare to see new designer drugs. The instruments and conditions used are summarised below [Guéniat et al., 1997][Guéniat, 2002].

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Hewlett Packard GCD G1800A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Injection</strong></td>
<td>Autosampler HP 7673</td>
</tr>
<tr>
<td></td>
<td><em>Split mode</em> 50 : 1</td>
</tr>
<tr>
<td></td>
<td><em>Temperature</em> 250 °C</td>
</tr>
<tr>
<td><strong>Column</strong></td>
<td>Capillary column,</td>
</tr>
<tr>
<td></td>
<td><em>Dimensions</em> 30 m x 0.25 mm I.D.</td>
</tr>
<tr>
<td></td>
<td><em>Stationary phase</em> DB-1</td>
</tr>
<tr>
<td></td>
<td><em>Film thickness</em> 0.25 µm</td>
</tr>
<tr>
<td><strong>Carrier gas</strong></td>
<td>Helium</td>
</tr>
<tr>
<td></td>
<td><em>Flow</em> 1 ml/min</td>
</tr>
<tr>
<td><strong>Oven temperature programme</strong></td>
<td>150 °C (for 1 min),</td>
</tr>
<tr>
<td></td>
<td>250 °C,</td>
</tr>
<tr>
<td></td>
<td>320 °C</td>
</tr>
<tr>
<td></td>
<td>ramp 8 °C/min to</td>
</tr>
<tr>
<td></td>
<td>ramp 6 °C/min to</td>
</tr>
<tr>
<td><strong>Detection</strong></td>
<td>MS detector</td>
</tr>
<tr>
<td></td>
<td><em>Interface temperature</em> 330 °C</td>
</tr>
</tbody>
</table>

*Table III.4.1: Description of the GC-conditions and the instrument used.*
The sample preparation was chosen so as to get information about the active substances as well as other products such as diluents and, more particularly, sugars. Therefore, the method includes a derivatisation of the sample with N-methyltrimethylsilyl trifluoroacetamide (MSTFA), as described below.

1. Dissolve 5 to 8 mg of homogenised sample powder in 500 µl chloroform: pyridine (5:1) (1 mg/ml heneicosane as the internal standard) and add 100 µl MSTFA.

2. Heat the solution for 1 h to 80 °C. Then cool down to RT within 10 min.

3. Inject 2 µl of the solution.

In particular cases, it was necessary to analyse underivatised samples in order to identify particular compounds, especially certain medical active substances.

The above method of analysis was not used for quantitation because of the following two determinant factors: a) the derivatisation of amphetamine-like substances is problematic and incomplete. Therefore, in some cases, more than one peak is present for the same substance (because of simple and double substitution of functional groups, for examples); b) an MS detector is not the best choice for quantitative analysis. Tests have been made with other, more selective derivatisation reagents, but in these cases other problems appeared, such as interference of the reagent itself with other compounds.

Qualitative analysis was normally performed on just one tablet per seizure (or one tablet per sort of tablet in a seizure) in order to save time. In special cases, additional analyses were made to confirm the results.

➢ **Purity of the illegal substance**

A quick and easy analysis method has been chosen for the quantitative analysis, viz., capillary zone electrophoresis [Esseiva et al., 1997]. Conditions were set as follows.

<table>
<thead>
<tr>
<th><strong>Instrument</strong></th>
<th>Hewlett Packard 3D CE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Injection</strong></td>
<td>Hydrodynamic injection</td>
</tr>
<tr>
<td></td>
<td><strong>Pressure</strong> 50 mbar</td>
</tr>
<tr>
<td></td>
<td><strong>Time</strong> 1 s</td>
</tr>
<tr>
<td><strong>Column</strong></td>
<td>Extended light path</td>
</tr>
<tr>
<td></td>
<td><strong>Dimensions</strong> 56 cm x 50 µm I.D.</td>
</tr>
<tr>
<td><strong>Voltage</strong></td>
<td>30 kV</td>
</tr>
<tr>
<td><strong>Oven temperature</strong></td>
<td>30 °C</td>
</tr>
<tr>
<td><strong>Detection</strong></td>
<td>UV-DAD, 214 nm</td>
</tr>
</tbody>
</table>

*Table III.4.2.: Description of the CZE-conditions and the instrument used.*
The aqueous solution was prepared as follows.

1. Dissolve 15 to 20 mg homogenised sample powder in 5 ml buffer solution at pH 2.35 (33.73 ml 0.1 M NaH₂PO₄ and 25 ml 0.1 M H₃PO₄) (0.2 mg/ml nicotinamide as the internal standard).

2. Vortex and sonicate the solution.

3. Filter the solution.

4. Analyse the filtered aqueous solution.

Double analysis of two different aliquots was regarded as being sufficiently accurate for intelligence purposes. Further analyses were made when necessary.

III.5. DATA MANAGEMENT INSTRUMENTS

A crucial point in intelligence work, as in other science branches, is the management of the archived data. It has to be simple, rapid, useful, and meaningfully structured. The compatibility of systems is also of high importance, especially when working in a wide network of actors (different laboratories, different police services, etc.). A large variety of different softwares is available on the market, often in comparable quality. The method chosen was dictated by availability.

- **Database**

  All data concerning ecstasy seizures and cases were collected and stored in a structured database built up with the software:

  *Filemaker™ Pro 4.1™.*

  This software provided for an easy handling of the archive of data. Its two main advantages were a simple interactive interrogation and the possibility of adapting the database structure without the assistance of specialised programmers. Good compatibility with other tools used in criminal analysis was demonstrated. The layout of the data in the database DonneeECSTASY99 is illustrated in the following figure.
Masks for consultation were prepared in French, English, German, and Italian. Photographs were stored in a separate database ImageECSTASY99 directly connected with the main database DonneeECTASY99 by a pointer relationship.

As described later on, one record of the database represented one seizure. A few characteristics (as for example the diameter, the weight, etc.) were introduced in a record sheet for every single measured tablet. To extract these data from the database for further statistical analysis, it was necessary first to export the data set to an intermediate clone of the database while separating the single measurements on different records. In a second step it was then possible to export them to an Excel 97™ sheet, for example.

- **Statistical evaluation**

Comparison and other statistical evaluation of numerical and other types of data at a case/seizure level as well as at a tablet level were made using Microsoft Excel 97™.
Analysis of data

Ordinary Microsoft software was used for presentation and transmission of analysis results for use in an

*I2 Analyst’s Link- and Case-Notebook™*.

This has been used to represent analytical results in a graphical and temporal dimension. This software has been developed for the visual representation of relations in criminal investigations and is commonly used by different police services. For some applications

*IBase™*,

a database system completely compatible with the *I2 Analyst’s Notebook™*, was used as an interface-to and data structure in the original *Filemaker Pro 4.1™* database.
IV. RESULTS AND DISCUSSION

IV.1. SAMPLING ISSUES

IV.1.1. Information potential of drug exhibits

For a better understanding of this research, the fundamental initial hypothesis described in the introductory chapter will be elaborated below.

All drug exhibits are a potential source of information.

Actually, for the attentive reader this sentence is the logical deduction of one of the basic principles of forensic science, the principle of individuality:

“Two objects may be indistinguishable but no two objects are identical.”
Robertson and Vignaux, 1995

A more elaborate description was given by Paul L. Kirk [Kirk, 1963]:

“A thing can be identical only with itself, never with any other object, since all objects in the universe are unique. If this were not true there would be no identification in the sense used by criminalists.”

Therefore, it is the fundamental task of forensic scientists to identify characteristics, establish and provide an interpretation of their individuality. In forensic science, the identification process ultimately seeks individualisation, and the problem of identity of a source often is treated by making reference to “class” and “individual” characteristics [Champod, 2000]. The idea is to look at the quantity of characteristics shared by two objects.

We may justifiably question why we need to make this so explicit when it is so evident? It is probably more for historical reasons that drugs exhibits always had a special position in the forensic sciences. Drug analysis has been, and still is, restricted mainly to the identification of illegal substances. The linking of exhibits, and therefore the interpretation of individualities, is not applied in drug analysis, and often this possibility is not even known to so-called “forensic analysts”.

It is a very important result of this hypothesis, therefore, to underline that characteristics of the drug exhibits themselves can give additional information about illegal synthesis and production ways and, indirectly, about illegal traffic. This is perhaps an unusual way of looking at drug exhibits, but it is evident and a common business in many other forensic activities. This classification of drugs, which occurs with the purpose of pointing out links between different seizures, is the main subject of this research work.
IV.1.2. **Representativity of the sample population**

For evident legal limitations, only tablets seized by police services were taken into account in this research work. It is general knowledge that the amount of drugs seized by police services only represents a small part of the true illegal market (estimates indicate that it is less than 10% of the total amount). Therefore, two initial conditions were laid down to at least increase the representativity of the population studied.

(i) The samples had to be collected from all ecstasy seizures that had occurred in a distinct region (Canton or city for example), and (ii) different geographic regions had to be included so as to have a representative population of ecstasy tablets sold and consumed in Switzerland.

![Figure IV.1.2.1: Sampling regions.](image)

Because of the existence of ongoing research contacts, seizures in the following five different regions:

- City of Zurich (ZH)
- Canton of Zurich (ZH)
- Canton of Ticino (TI)
- Canton of Neuchâtel (NE)
- Canton of Geneva (GE)
could be selected and analysed on a regular basis. In addition, seizures from other regions such as the Canton of Vaud or the city of Lausanne were analysed. These different regions also cover the three linguistic regions of Switzerland: the French-speaking part (NE and GE), the German-speaking part (ZH), and the Italian-speaking part (TI) of Switzerland.

This population also represents geographically and socially different situations extending to about 30% of the total Swiss population. The region south of the Alps (TI) is economically influenced by the northern Italian market, and particularly by its proximity to the metropolis of Milan. Hence, illegal ecstasy traffic may hypothetically be more strongly linked to the southern European traffic, and include other types of samples. The city and Canton of Zurich (ZH) represent a highly industrialised region north of the Alps, including the largest city of Switzerland. Its economic and cultural exchange is mainly under German influence, and more open to new cultural movements such as the techno culture. The regions of Neuchâtel and Geneva are more strongly influenced, both economically and culturally, by France. In this context, Neuchâtel represents a more marginal industrial and cultural region; Geneva instead is the symbol of the international political and para-political life of Europe and the World. This international influence could also have an impact on the illegal activities identified in its territory.

From a quantitative point of view, Swiss federal statistics of 1998 and 1999 showed that the cases concerning ecstasy seizures in these 5 regions represented between 45 and 50% of the total number of national ecstasy seizures [OFP, 1998 – 1999].

The predominance of the seizures in the more highly “metropolitan” region of Zurich is evident, and also logical. More than 35% of the total number of cases in 1998 were seized in Zurich. Within the database, this means that samples coming from the city police of Zurich represent about 58% of the seizures.

*Figure IV.1.2.2.: Number of ecstasy cases recorded in the cantons of Zurich, Ticino, Geneva and Neuchâtel in 1998 and 1999 according to the federal statistics.*
From a practical and organisational point of view, it was not possible to obtain and analyse samples really representative of all seized cases in these four regions. According to the legal situation in Zurich, seizures of only one or two tablets could not be submitted to analysis, because these samples had to remain available to the court for a determined period of time. The following coverage was attained:

<table>
<thead>
<tr>
<th>Police service</th>
<th>Transmitted seizures</th>
<th>Regularly since</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canton Ticino</td>
<td>All seizures</td>
<td>January 1994</td>
</tr>
<tr>
<td>City of Zurich</td>
<td>Seizures &gt; 2 tablets</td>
<td>September 1996</td>
</tr>
<tr>
<td>Canton Zurich</td>
<td>All seizures</td>
<td>September 1996</td>
</tr>
<tr>
<td>Canton Neuchâtel</td>
<td>All seizures</td>
<td>January 1998</td>
</tr>
<tr>
<td>Canton Geneva</td>
<td>All seizures</td>
<td>July 1999</td>
</tr>
</tbody>
</table>

*Table IV.1.2.1.: Regularly transmitted seizures of ecstasy tablets.*

The following figure shows the number of ecstasy seizures made in the city of Zurich and the relative number of cases transmitted for the present research work.

*Figure IV.1.2.3.: Cases of ecstasy seized by Stadtpolizei Zurich.*

From April 1997 to June 2000, 49 % of the cases seized in the city of Zurich were sent to the laboratory. Even if the effective number is quite low, these cases represent 99 % of the total number of seized tablets (about 66 400 tablets of the total of 67 000 seized tablets). The cases not transmitted for this study nearly exclusively concerned the consumer level. Instead,
all potential and low level-dealers assumed to yield more information about the illegal market are included in this research.

Additionally, one sees that there exists a variation in the seizures in time. It seems that the months of January, August, and April-May are those where the proportion of consumer cases is quite high. In the beginning of August, the organisation of the Street Parade in Zurich (Techno manifestation which attracted nearly a million of young people in 2002) has large influence.

Within the national ecstasy seizures, it can be admitted, therefore, that the chosen population is representative; it represents a large quantity and covers at least four distinct regions.

The question remains whether police seizures are representative of the illegal market itself or whether the use of drug exhibits from the police could imply a higher density of series and linked groups, as seizures are the result of combined investigation or local organised police operation.

To be representative of the entire illegal ecstasy market, ideally it would be necessary to do a sampling directly and personally where the deal is going on; for legal, ethical, and organisational questions this was not pursued.

Similar to Germany, a private organisation located in Solothurn (Switzerland) operates under the name of “Eve & Rave”. It is described as a company for the promotion of party and technoculture and for the alleviation of drug problems [Eve & Rave, www]. Partly with the help of the Swiss federal health department, since 1997 Eve & Rave have been testing ecstasy tablets in the context of preventive actions. Consumers themselves (and/or dealers, of course) send the tablets directly to Eve & Rave for analysis, and the results are published in the web in the form of an anonymous list [Eve & Rave, www]. This list contains some chemical and physical information about new types of tablets that appeared on the techno scene over the years (as well as photographs of the logos since 1998). An example is shown below.

![Figure IV.1.2.4: Chemical and physical information of ecstasy tablets as presented in the webpage of Eve & Rave.](image)

The following statistical comparison was manually performed between the two lists of results (by Eve & Rave and by police seizures), mainly comparing the appearance in terms of
imprints and colours over the period from 1998 to November 2000 [Eve & Rave, 1998 – 2000]. Tablets without logos and capsules were not included in the comparison.

<table>
<thead>
<tr>
<th>From 1998 to 2000</th>
<th>Number of new identified logos (sorts of tablets)</th>
<th>Types of tablets present in both data sets</th>
<th>% of similarity</th>
<th>% of types of tablets not present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eve &amp; Rave</td>
<td>136</td>
<td>104</td>
<td>76.5</td>
<td>23.5</td>
</tr>
<tr>
<td>Police seizures</td>
<td>137</td>
<td>104</td>
<td>76</td>
<td>24</td>
</tr>
</tbody>
</table>

*Table IV.1.2.2.: Comparison of data gathered from police seizures and Eve & Rave collection.*

This table shows that about 75% of the new types of tablets are recorded irrespective of the sampling method (police seizures vs. consumers). 25% of the new tablet types were not found in seizures by the police, but on the other hand, again 25% of new tablet types seized had not been reported by consumers to Eve & Rave. These data indicate that the population “police seizures” is rather representative of the actual illegal market of ecstasy tablets.

The comparison between the Eve & Rave XTC test results and the results for the police seizure samples is interesting, because the sampling occurred in the same illegal market, but with a completely different philosophy and methodology of collection. The two sampling populations may therefore be considered as distinct and having a low correlation.

In conclusion, the above data support the hypothesis that

**drug exhibits seized by police are representative of the illegal ecstasy market.**

More particularly, it is possible to affirm that the chosen sample population is representative of the Swiss illegal ecstasy market. The question remains whether this market is uniform within the country or shows geographical particularities.

**IV.1.3. Temporal representativity**

The third hypothesis was a temporal consideration:

*Investigation methods based on forensic science are stable over time and can be used to analyse the illegal drug market on a strategic and operational level.*

At this point it is not possible to provide further indications supporting this hypothesis, especially with respect to the temporal stability of investigative methods. It is possible and necessary, however, to insure temporal representativity of the sample population of ecstasy tablets.
In fact, the production and traffic methods are changing, hence also the variants of ecstasy tablets found in the illegal market are changing physically and chemically with time. The analysis of different classes (as described further on) shows that one sort of tablets is present in the illegal market, normally over a period of 5 to 8 months. Sometimes the same type of tablet reappears months later (as for example in the case of classes 6 and 7 in the following figure).

<table>
<thead>
<tr>
<th>Class number</th>
<th>Class name</th>
<th>Lifetime [months]</th>
<th>Total of seizures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rose</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>Adidas</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Simba</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>Letter S</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Neuchâtel</td>
<td>6</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>ColStrie</td>
<td>6 + 8</td>
<td>39</td>
</tr>
<tr>
<td>7</td>
<td>Jumeaux</td>
<td>5 + 2 + 5</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>Ferrari</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>9</td>
<td>Euro 8</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>RAableu</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>WarnerBros</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

*Table IV.1.2.3.: Lifetime of different classes.*

According to these data, it appears essential to be able to trace records back at least one to two years. Some cases have been analysed over more than five years, but for the sake of coherence statistical and general evaluations have been made for a period of about three years only (from April 1997 to June 2000). This choice was made to insure the inclusion of a numerically complete, representative set of seizures during this time. In fact, before April 1997 for some seizures certain information was not available or particular characteristics were not analysed. After June 2000 the collection of ecstasy data continued, but for the sake of experimental analyses a closed set of seizures was chosen.
Another interesting temporal information would be to know how long it takes from the moment that a new type of tablets appears on the illegal market until it is seized for the first time. Of course, with the information collected here, it is not possible to make a precise determination of this time. But again, it is interesting to compare the list of new tablets from police seizures with the list of new tablets collected and published by Eve & Rave from 1998 to November 2000 [Eve & Rave, 1998 – 2000]. Unfortunately, this comparison can only be made on a yearly basis.
From 1998 to November 2000, on an average 75% of the cases are found in both lists. From this figure it is possible to deduce that in 1998, only 3.3% have been reported by consumers to Eve & Rave before they have been seized by a police service; in 1999, this figure was 6.9%. On the other hand, in 1998 the police had seized 20% of the cases prior to any registration by Eve & Rave; in 2000, this figure was 23.2%. These tablets appeared in the Eve & Rave lists, only one year later. Even if it would be more appropriate to analyse this problem on a monthly basis, it can be seen from the annual figures that police seizures of ecstasy tablets occur in a timely fashion and represent the actual samples of the illegal market. It is even possible to affirm that police detected new “trends”, new arrivals before they were detected by organisations allegedly close to the scene.

One natural hypothesis to explain this fact is that through constant investigations, police may be closer to the providers. Therefore, it can happen that new seizures are stopped or intercepted in a timely fashion before they spread out to the consumers.

**IV.2. PHASE I + II: DATA ACQUISITION AND EVALUATION**

**IV.2.1. Introduction**

In the original thesis project [Zingg, 1999], four different principal objectives were fixed, and it was proposed to divide the research work into four distinct phases (I, II, III and IV). Already at that time a chronological investigation was planned, but with the possibility of admitting an interactive and iterative reorganisation. In order to summarise the results of this study in an appropriate way, it has been decided to merge the first and second phase. It is for this reason that the results are discussed in the following three, rather than four sections.

I+II. **Data acquisition and evaluation**, with particular emphasis on the methods of analysis which have been used and tested for their differentiating value for the purposes of intelligence.

III. **Linking process and analytical methodology**, emphasising the definitions of links and the description of temporal and graphical methodologies of analysis.

IV. **Test and validation**, showing examples of practical applications in routine police work.

**IV.2.2. Definition of a data structure**

The construction of a database can never be a final aim in itself. All types of data can be organised in databases so that it will be possible to find the right “entities” and their connected characteristics and descriptions in a multitude of information. In a database, it should be possible to find the information within a reasonable time lapse, and at the right place.

A perpetual dilemma of databases is the level of detail, precision and accuracy of the information stored. Databases are often either too general or too detailed; in both situations, it will not be possible to find the information needed at the appropriate time and place.
Databases containing drug analysis results are commonly used, but mostly for purely statistical purposes. Unfortunately, the information needed in an intelligence perspective is generally not available in existing databases. It was necessary, therefore, to design a new structure for the storage of collected data on ecstasy seizures. The main characteristics of this database were chosen as follows:

1. Include general forensic information of different seizures in order to classify them (harmonised case information).
2. Enable the classification of new entries within a short time lapse.
3. Acquire unique references from other cases in order to obtain samples for further examinations.

The following paragraphs provide the definitions and general structure of the database used, which proved to be functional for fieldwork. A tiered system was chosen to process ecstasy seizure data according to the following figure.

![Diagram of database structure](image)

*Figure IV.2.2.1.: General structure of the seizures handling and the database structure.*

The case is defined by the police service itself. It may for example constitute a search of a particular room or other place; or it may represent the summary of acts committed by one person or a group of persons, and so on. It is important that there be provided a unique and unmistakable reference number to any event. A case could be part of a large police operation.
Following the basic principles of crime scene investigations, a **seizure** is described as a subunit of the case, and may have a specific identifier within the case as to location, time, etc. Every clearly distinguishable seizure of bags or other recipients containing ecstasy tablets is treated independently. If for example during a search of an apartment, three bags containing tablets are found in three different places, they will be registered as three separate seizures. Even if their appearance is the same they should not be mixed. The seizure is characterised by a time of seizure, a place of seizure and a total number of ecstasy tablets per seizure.

A seizure normally contains very similar tablets. On a general level, such tablets are visually and physically indistinguishable. Implicitly they belong to some same sort of tablets. This broad classification makes it possible that mean values be used.

It is in some rare cases only that two or more sorts of tablets are present in the same seizure. One example was the seizure of tablets with the imprint of Tom, mixed with tablets with the imprint of Jerry present in the same bag. In such a case it is necessary to differentiate different sorts of tablets in the seizure. Another example was a bag (seizure) of 20 apparently similar tablets. After measuring the thicknesses, two different groups were identified, one with thicker tablets and one with thinner tablets. It was then necessary to separate these tablets into two subgroups.

It has to be pointed out that for a laboratory receiving “representative” samples, a subdivision into different sorts is not always possible, since no information may have been transmitted as to the original packaging of the tablets.

Therefore, most of the seizures collected correspond to sorts of tablets, and in practice the distinction is rarely made. Often a codification of the sort of tablet is simply omitted.

A **tablet** finally is the lowest possible entity. Visual, physical, and chemical characteristics are measured within the uncertainties of the methods. Sometimes capsules seized as ecstasy were measured and recorded as well.

In harmony with the above structure of data handling and in order to store basic information already in a sort of code, the following numbering system was set up for codifying the samples and related data:

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Seizure</th>
<th>Sort</th>
<th>-</th>
<th>Tablet</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is a composition of various elements</td>
<td>Current alphabet letter</td>
<td>Current number</td>
<td>Incremental numbering</td>
<td></td>
</tr>
<tr>
<td>Date of seizure</td>
<td>Origin</td>
<td>Lab</td>
<td>Current number</td>
<td></td>
</tr>
<tr>
<td>9904</td>
<td>ZS</td>
<td>Z</td>
<td>1339</td>
<td>A</td>
</tr>
</tbody>
</table>

99=year  
04=month  
XX=not known  
ZS=Zürich Stadt  
ZK=Zürich Kanton  
TI=Canton Ticino  
GE=Canton Genève  
NE=Canton Neuchâtel  
Z=WD  
L=IPSC  
For each Lab its own number  
Given only when more than one sort of tablet is present within the same seizure  
Table IV.2.2.1: Seizure numbering system.
In practice, only the Lab code (Z for WD and nothing by default for IPSC, which has now been changed to L), the current number and the current alphabet letter were used to describe the seizures (for example seizure 1123A, seizure Z24D, and so on).

No personal data were integrated into the base in order to avoid all problems of personal data protection laws and allow the free exchange of technical data. Each authority can go back to its own personal data files via the reference number of the case.

For forensic intelligence purposes, the classification was more specifically made on the basis of data at the level of sorts, which very often coincides with the seizure.

This organisation of data represents a fundamental way of intelligence thinking. The numbers and letters are not merely a code for retrieval of any particular case, but already provide important information to the chemical and criminal analysts. Temporal, geographic, and basic information on a seizure which is useful at every stage of intelligence analysis is included in the full code.

IV.2.3. **First and second-priority analysis methods**

**IV.2.3.1. Introduction**

Classical criteria for the evaluation of an analytical method are its selectivity, reproducibility, sensitivity, trueness, costs, and the simplicity of measurements. In forensic intelligence, one of the essential criteria is the time factor (rapidity). In the investigative process, even the best information is useless if it arrives late. According to these factors, the various types of data and of analytical methods have been divided into first and second priority.

First-priority analyses are measurements routinely required in order to obtain a minimal data set suitable for classification purposes. The methods chosen have already been presented.

Second-priority analyses are measurements that can be used for a more specific description or comparison in a second step designated to refine, verify, validate, and test hypotheses. These methods normally are applied only to a restricted number of tablets or sorts of tablets from seizures covering the same class or a similar type of tablets. Analytical methods of this type do not have to be defined in advance but can be evaluated in accordance with the additional data needed.

In the following subsections we discuss results, advantages and disadvantages, as well as some comparative studies within various first and second-priority analytical methods and their value in terms of discriminating power, classification potential and comparative power.

**IV.2.3.2. Visual characteristics**

- **Imprint description, name and imprint code**

  (= text, text, numerical code)

By June 1999, one out of any three seizures present in the database (with records since 1995) did not have any imprint on the tablets. The following figure is a representation of the distribution in the period from January 1997 to August 2000; it shows that by this time the
proportion of seizures having tablets with an imprint increased to two in three seizures. This tendency appears to persist.

![Imprint distribution from January 1997 to August 2000 (Total of 1093 seizures)](image)

Figure IV.2.3.2.1: Imprint distribution from January 1997 to August 2000 (Total of 1093 seizures).

Therefore, the use of a correct imprint classification becomes more important. In the following table seven examples of imprint codification are shown.

<table>
<thead>
<tr>
<th>Photo</th>
<th>Internal number</th>
<th>Imprint description</th>
<th>Name</th>
<th>Imprint code</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Image" /></td>
<td>560B</td>
<td>Moineau (sparrow)</td>
<td>Moineau, sparrow, bird</td>
<td>028</td>
</tr>
<tr>
<td><img src="image" alt="Image" /></td>
<td>540</td>
<td>Signe de Adidas (Adidas mark)</td>
<td>Adidas</td>
<td>199</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Imprint Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>554</td>
<td>Cor de chasse (hunting horn)</td>
<td>Cor de chasse, crab, prawn</td>
<td>248</td>
<td></td>
</tr>
<tr>
<td>978B</td>
<td>Tête avec triangle (Teletubby) (Head with triangle)</td>
<td>Tête avec triangle, Teletubby, Tinky Winky</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>568</td>
<td>Tête de bébé avec un cheveu (Head of baby with hair lock)</td>
<td>Bébé, Teletubby Po</td>
<td>194</td>
<td></td>
</tr>
<tr>
<td>844</td>
<td>Ecriture N° 1 (Numeral 1)</td>
<td>Numéro 1, number 1</td>
<td>193</td>
<td></td>
</tr>
<tr>
<td>937A</td>
<td>Ecriture 007 (Numerals 007)</td>
<td>007, James Bond</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Table IV.2.3.2.1.: Examples of name and imprint description.

As described before, three distinct but highly correlated ways were used to codify the appearance of the imprint. Every one of these codifications has its own advantages and disadvantages, but their combination yields an efficient tool for finding preexisting imprints and the related seizures.

The imprint description is the simple description of the observation made according to a structured list of descriptions of imprints. All new imprints are first compared to the entries in
the list of descriptions encountered previously (Annex 3: List of recorded imprints from January 1997 to August 2000). In this way an unambiguous codification is insured, and similar imprints will all be described with exactly the same text in order to facilitate database-search actions. All new appearances of imprints are included in the list of descriptions by the operator himself giving a simple description of the image of the imprint. The selectivity and the reproducibility of this imprint description are of high quality, as all codification depends on the complete list of other, similar seizures. However, such a text-related system has the disadvantage of a strong dependence on language (in this case, French) and of a rather low degree of liberty in describing imprints.

The introduction of a free-name description of the imprint unrelated to any list of pre-existing words has provided a tool offering a high degree of liberty which is extremely useful in search actions prior to the definite codification of newly encountered imprints. Particularly the introduction of certain descriptive foreign or slang words for certain types of imprints proved to be efficient. A codification system based on textual codes strongly depends on the search possibilities of the database software. This is actually one of the advantages of Filemaker Pro 4.1™, where it is possible to search for an exactly defined text but also for part of a text (beginning of a word, a word in the middle of a sentence, signs, and so on).

A numerical code was considered with a view to solving the language problem, but it was decided not to introduce a new numerical codification system of imprints. Instead the EUROPOL codification has been used. This codification has the advantage that it already exists on an international level. In fact, it can be used for exchanging data and referencing independently of the language. The main disadvantage of this code is its lack of systematic structure. In fact, the EUROPOL code (previously known as EDU code) began as a simple numbering of newly appearing imprint types. A degree of systematic structure has later been introduced when subclasses were created in the EUROPOL CD for easy searching. This codification sometimes (but not always) includes colours or other aspects useful for differentiation. For example, in the figure of “Fido-Dido” the code 036-1 is used for beige tablets, the code 036-2 is used for pink tablets; in the records of “Mitsubishi” tablets various subgroups have been created, probably in relation with other physical characteristics (shape, thickness, colour, and so on). This subclassification is not systematic, and the criteria are not defined for the end users. That is why the EUROPOL code was used in our database, exclusively to describe the imprint, when such codification existed.

In the period from January 1997 to August 2000, 232 different imprints have been identified and listed. Only 50% of them had already been classified in the EUROPOL system. From available statistical data one can see the dynamic evolution of the imprints. In fact, by June 1999 only 177 different imprints had been listed, which means that within another 15 months (from June 1999 to August 2000) 55 new imprints were recorded. This is an increase by about 30%. During the same time other imprints “disappeared” (as for example the crown present in the “Neuchâtel” class). Today none of the imprints recorded in the beginning of this project reappears in new seizures. This large number and diversity of the different imprints is of course an excellent means of discrimination.

In special high-profile cases with many important seizures, it was necessary to have a more detailed codification of the imprint. In these cases an additional internal (alpha-)numerical codification was introduced. One complex example is the case of tablets having the writing “WY”. In a first step, four different types were created.
Table IV.2.3.2.2: Four different types of “WY” imprint.

Within every type of the “WY” lettering, other subtypes were found and described, depending only on visual comparison of the imprint. An example is given in the next table for Type C.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>Y vertical</td>
</tr>
<tr>
<td></td>
<td>Y longer than W</td>
</tr>
<tr>
<td>Type B</td>
<td>Y vertical</td>
</tr>
<tr>
<td></td>
<td>Y same as, or shorter than W</td>
</tr>
<tr>
<td>Type C</td>
<td>Y inclined</td>
</tr>
<tr>
<td></td>
<td>Y longer than W</td>
</tr>
<tr>
<td>Type D</td>
<td>Y inclined</td>
</tr>
<tr>
<td></td>
<td>Y same as, or shorter than W</td>
</tr>
</tbody>
</table>

Table IV.2.3.2.3: Different “WY” imprints of type C.
The introduction of categories of imprints (for example animals, labels, and so on) would be helpful in the search for existing imprints, especially in databases not computerised. In the latest edition of the EUROPOL booklet [EUROPOL, 2000], such an attempt was made, but it would be useful now to also adapt the numerical codification to these categories. This improvement would facilitate the handling irrespective of language.

The codification system of the imprints described in this section was found to be simple and efficient as well as less time consuming for data over a three-year time period.

Other methods could be of interest. The most interesting one would be an automatic analysis of the imprint in an image, directly by pattern recognition methods. This would work well with centralised databases.

**Breaklines**

The codification of breaklines is evident and provides a simple further descriptor. No cases of false positive or false negative are known until now, even if theoretically it is possible to imagine tablets with invisible scoring. The selectivity of this characteristic is of course not so high, but as shown in the figure below, it yields an important additional discriminating factor.

![Breakline distribution from January 1997 to August 2000](image)

*Figure IV.2.3.2.2.: Breakline distribution from January 1997 to August 2000.*

The correlation matrix comparing the presence of a breakline with the presence of an imprint shows that no correlation can be drawn between these two different characteristics. 50 % of the tablets with imprint have a breakline, another 50 % do not have a breakline.
Correlation matrix

<table>
<thead>
<tr>
<th></th>
<th>With imprint</th>
<th>Without imprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>With breakline</td>
<td>455</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>79% with an</td>
<td>21% without an</td>
</tr>
<tr>
<td></td>
<td>imprint</td>
<td>imprint</td>
</tr>
<tr>
<td>Without breakline</td>
<td>335</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>75% with an</td>
<td>25% without an</td>
</tr>
<tr>
<td></td>
<td>imprint</td>
<td>imprint</td>
</tr>
<tr>
<td></td>
<td>58% with a</td>
<td>51% with a</td>
</tr>
<tr>
<td></td>
<td>breakline</td>
<td>breakline</td>
</tr>
<tr>
<td></td>
<td>42% without</td>
<td>49% without a</td>
</tr>
<tr>
<td></td>
<td>a breakline</td>
<td>breakline</td>
</tr>
</tbody>
</table>

Table IV.2.3.2.4.: Matrix of the number of tablets with/without imprint versus with/without breakline.

Within a given kind of imprint, as for example the “Mitsubishi” class, there are tablet types with a breakline and others without a breakline.

In other projects an attempt had been made to measure the scoring for the purposes of comparison. The combination of length and angle measurements by typical ballistic instruments gave poorly reproducible data [Kummer, 1998], contrary to earlier results [Portman, 1996].

➢ Tablet shape

 (= alphabetic code x 3)

As indicated earlier, the description of the tablet’s shape is the result of a quick visual classification based on a limited basic geometrical appreciation by the operator. Other known methods to describe a tablet’s shape are mostly based on a textual description or a geometric figure.

The codification method proposed here has several advantages. The definition of a tablet orientation makes codification unique and thus eliminates ambiguous codification. The three-letter code yields a universal and simple standard that is independent of language. It is suitable for searching and, hence, for classification purposes. The subdivision into three distinct and independent letters allows a much more flexible handling of the code. It allows, for example, a search to be performed according to shape characteristics even where doubts exist as to one of the codified sides.

The choice of possibilities has on purpose been reduced to a minimum. This serves to minimise false negative comparison. Other codification systems, for example, differentiate between completely flat sides with a rectangular rim and flat sides with an oblique rim. Practical experience shows that it is not always possible to see this difference, which is due to poor quality of tablets easily losing such features (for example during transport).

On the other hand, the codification proposed does not provide any measure of convexity or shape of the (rectangular) rim. It is not possible to exclude miscodification. It is possible to imagine, for example, that a C-type side would be codified as a B-type (Annex 4: The three-letter system for the codification of the tablet shape), especially when their quality is low. Boolean search tools can be used in the database to overcome this problem. In fact, the
interactive character of the Filemaker Pro 4.1™ database allows one to simultaneously search for different codes and even undefined codes.

Statistical analysis of the classes can help to quantify the impact of miscodification. The classes (see below) are defined as a group of seizures/sorts with comparable morphological and/or chemical characteristics. The tablet shape code of different seizures belonging to the same class is supposed to be the same. Depending on the operator, time and day of the measurements, different codifications may occur, however.

![Graph](image)

**Figure IV.2.3.2.3.: Number of classes without or with differences in tablet shape codification versus number of operators.**

This figure shows that of a total of 46 different types of tablets (classes), eight (17%) were given a different shape codification. Contrary to expectation, this does not depend on the number of operators. It appears that miscodification is a result of poor quality of the samples, rather than of questionable abilities of the operators (Annex 4: The three-letter system for the codification of the tablet shape).

What kind of confusion exists with respect to shape of the sides, and what kind of miscodification may result? The following figure provides details concerning instances of miscodification encountered in the eight classes described previously.
Figure IV.2.3.2.4.: Variation within the different classes.

In the classes shown, errors mainly appear when qualifying the shape of sides of the C and B-type (flat with border and flat). In just one example (class Lapin) there was confusion between a B and an A-type side.

As more seizures are included and more measurements are made, misidentifications are seen to decrease. According to these results, it is possible to affirm that the reproducibility and sensitivity of the above tablet shape codification are acceptable.

In an effort to evaluate the selectivity and the value of this codification system, the frequency of the three-letter code has been calculated over the entire database, as shown in the following figure.
This graph shows that more than 60% of the seizures have a shape of the RAA or RBB type. An evaluation of every single code letter is not of interest, since for example more than 90% of the seizures are round tablets. About 45% are A, another 45% are B-type codes.

The above graph shows an acceptable selectivity. The fact that the system of three-letter codes gives rise to a simple and very quick method of classification makes it very powerful. No other second-priority analysis methods have been investigated in detail. Some tests have been made using calibrated photography, and revealed a good potential for further development [Gobry and Zingg, 2000]. With this method, the one-to-one comparison and the classification (of convexities for example) could be significantly improved, but on the other hand this would imply that all samples had to be photographed, and it would be necessary to calculate mean values of the dimensions, which would be very time-consuming and expensive.

**Colour**

(= alphabetical code)

At the beginning of this research project, a free-text description of colours similar to that of the imprint name was used. This resulted in a number of incompatible descriptions, which became a major problem when comparison was required. Because of this large variety of descriptions, it was not possible to find corresponding classes of seizures. Therefore, the following method involving a predefined choice of colours was introduced, rather than performing the strenuous colour coding using reference tables that is used, for example, in paint comparison.

This method is rapid, quite simple, and cost-effective. The use of a standard light source proved to be effective in reducing the variety and, therefore, increasing the reproducibility of results even between different laboratories. The following figure shows the variation of colour codification within a given class of tablet seizures for a set of operators.

![Number of classes without and with differences of colour codification](image)

*Figure IV.2.3.2.6.*: Number of classes without and with differences of colour codification.
This figure shows that of a total of 35 types of tablets falling into different classes, 13 (37 \% ) led to a different colour attribution. This is a much higher percentage than that found in tablet shape codification. A major reason resides in the fact that within a given class, seizures of the same laboratory but of different batches are regrouped. However, from batch to batch slightly different colours are possible, in contrast to the lack of shape variation between batches. In some cases different dyes are used to differentiate different batches of production; these were not included when evaluating the reproducibility. In conclusion, the reproducibility of the above colour codification is not perfect, but it is much better than an uncontrolled free-text colour description.

On the other hand, it can be seen that the reproducibility of colour codification to some extent depends on the number of operators. When three operators were involved in the colour codification work, two out of any three classes revealed codification differences. More differences in colour codification were also found when a single operator was recording the new seizures over a long time period.

The following table shows the classes that were a source of different classifications, and the colours that were often misinterpreted.

<table>
<thead>
<tr>
<th>Class</th>
<th>White</th>
<th>Beige</th>
<th>Gray</th>
<th>Orange</th>
<th>Red</th>
<th>Pink</th>
<th>Violet</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simba</td>
<td>19</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soleil007-5</td>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JamesBond</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro9</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port028</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paix</td>
<td>1</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XTriangle</td>
<td>1</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jumeaux</td>
<td></td>
<td></td>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailande rouge</td>
<td></td>
<td></td>
<td>69</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TesBBRouge</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ThioStar</td>
<td></td>
<td></td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DiamantVS</td>
<td></td>
<td></td>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adidas-bleu</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table IV.2.3.2.5.: Number of seizures with different colours codification within the same class.**
This table shows the 13 classes in which different colour codifications were attributed. It shows that the problem occurred in the following three colour combinations: white-beige-grey, orange-red-pink and pink-violet-blue. More than half of all classes were found within the colours white-beige. In 9 of the 13 classes (about 70%), a different colour codification was reached for only one or two seizures. In only two classes an important number of seizures were codified in a different way (42% of beige in the Simba class, and 22% of orange in the “Thailande rouge” class). In some cases, as for example in the “Thailande”-class, this also depends on the batch.

In an attempt to minimise this problem a reduction in the number of colour classification possibilities (for example, eliminating orange and pink, and merely retaining red) could be used to reduce the risk of wrong classification. The possibility of attributing “light” or “dirty”, as described in the methods section, increases the selectivity of colour codification. This possibility of recording additional information about the colour was introduced in the ENFSI-Forms [ENFSI, 2000] by adding a “colour particularity” descriptor.

The following table shows the frequency of colours within the total number of 1093 seizures.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Frequency in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>42.1</td>
</tr>
<tr>
<td>Beige</td>
<td>19.5</td>
</tr>
<tr>
<td>Rose</td>
<td>7.6</td>
</tr>
<tr>
<td>Orange</td>
<td>6.9</td>
</tr>
<tr>
<td>Green</td>
<td>5.8</td>
</tr>
<tr>
<td>Blue</td>
<td>5.7</td>
</tr>
<tr>
<td>Yellow</td>
<td>4.2</td>
</tr>
<tr>
<td>Red</td>
<td>2.4</td>
</tr>
<tr>
<td>Grey</td>
<td>2.2</td>
</tr>
<tr>
<td>Violet</td>
<td>1.6</td>
</tr>
<tr>
<td>Two-colour</td>
<td>0.8</td>
</tr>
<tr>
<td>Brown</td>
<td>0.8</td>
</tr>
<tr>
<td>Black</td>
<td>0.4</td>
</tr>
<tr>
<td>Not identified</td>
<td>0.1</td>
</tr>
<tr>
<td>Multicolour</td>
<td>0.1</td>
</tr>
</tbody>
</table>

This representation gives a clear idea of the distribution of colours in ecstasy tablets. On the illegal market from 1997 to 2000 in general, it is seen that the great majority of tablets are white or beige (about 62% of the seizures). Other colours such as pink, orange, green, blue, yellow, red and grey are rarer, but still are found on a regular basis. Compared to statistics made in 1997 when about 72% of the seizures were classified as white or beige, it is seen that over the past few years the use of dyes has increased, probably to make ecstasy tablets more attractive. Sometimes dyes are used as well to mask the off-white colours of major filling substances. Two-colour and dark tablets are an exception in this illegal market.
The graph above shows that the colour codification is a useful classifier for the classification of tablet classes.

This very simple and rapid method of classifying the colours was preferred over other systems, such as a codification using the Munsell Color Scale which is used in paint analysis [Massonnet, 1996]. These codification methods are too detailed for a strategic classification purpose, and are quite time-consuming. Such specialised methods are a source of reproducibility problems and introduce further interpretation problems. Other, simpler systems of colour codification such as the RAL code used in car paint description, or a handbook of colours [Methuen, 1961], have also been tested. These tests showed that the use of a simple colour table can be useful, only when restrictions apply as to the choices available. For this reason it was decided to stick to the method of colour codification described above.

For a second-priority analysis, the identification of dyes has been explored in detail elsewhere [Goldman, 2000]. This method yields good results when differentiating similarly coloured tablets. This can be an important factor in identifying subclasses or in distinguishing between different batches of ecstasy tablets. It represents a selective and sensitive method giving reproducible results. However, the cost and the time factor of this method of chemical analysis are too high for a first-priority method of analysis used for classification purposes. This conclusion had also been reached to some extent in the work of Goldman [Goldman, 2000], where the method was described as an additional discriminatory method, more useful in providing property profiles in the comparison of ecstasy tablets than from an intelligence point of view.

➢ **Photographs**

Photography is the most time-consuming step in the visual characterisation of ecstasy tablets. It represents the visual summary of all visual properties of the tablets described above. It does give a correct idea of the tablet and its imprint. It also includes “data” that are not codified, such as the degree of convexity of A-type shapes or an indication as to the “quality” of the tablet. Photographs, therefore, are the “flag” of a seizure and an essential step for the classification process, particularly in the very early phase of this operation. It is a useful and selective criterion for the disclosure of tablets showing obviously different characteristics.

Photography not only is the most time-consuming step, it also requires investments in instrumentation and equipment. The most important disadvantage, and to some extent a possible source of errors, is its reproducibility. In fact, the need for a standardized, uniform light source to get the exact impression of colour and on the other hand the need to use oblique light to highlight the imprint forms, often are in competition. This leads to difficulties in maintaining good reproducibility of photography, not only between different laboratories but also in intra-laboratory comparison. The large effects are demonstrated in the following three examples of the records of five different tablets obtained at different times by different operators.

In an effort to reduce these variations, a standardised and fixed, simple set-up has since been assembled at the IPSC [Margot, 2003].
<table>
<thead>
<tr>
<th>Subgroup</th>
<th>“Jumeaux”</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>610</td>
<td>Z11B</td>
<td>832</td>
</tr>
<tr>
<td></td>
<td>666</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>705</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>“ThioStar”</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>737</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>743</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>748</td>
<td>764</td>
<td>Z53C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>“Xtriangle”</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>550</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>563</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>570</td>
<td>858B</td>
<td>Z53F</td>
</tr>
</tbody>
</table>

*Table IV.2.3.2.6.: Examples of variation of photographs.*
These examples show the relatively wide range of colours recorded over time at the same sort of tablets. The image of seizure Z53C, moreover, gives an idea of different qualities sometimes appearing with the passage of time.

An important factor for these problems is the instrumentation itself. The characteristics of the computers and cameras have a high impact on the final results. Recording the same tablet with the help of two different computer screens, for example, can give different final images. Or, installing a different light source may give a different colour perception.

On the other hand, when using standardisation of the image and of the imaging scale, one can produce comparative overlays and compare similar imprints. This is an important second step of analysis when very similar imprints are present. An example of such an overlay is shown in the following example, made with Photoshop™, where the use of various “chalks” (technical description of different image versions in Photoshop™) with different opacities enhances similarities and highlights differences.

<table>
<thead>
<tr>
<th>976C</th>
<th>969</th>
<th>972B</th>
</tr>
</thead>
</table>

Table IV.2.3.2.7.: Comparison of imprints within Photoshop™.

In the first of these examples, it is seen how two tablets of different colour yield a nearly identical overlay of the imprints of the Ferrari horse. The second example shows that the
Even if the advantage of using standardised photographs of tablets is essential for database work, simple nonuniform images may be sufficient for the purposes of a general description. This nonstandard practice is the choice made in the ENFSI transmission guides for the description of ecstasy tablets.

In databases where detailed information is collected including dimensions of the tablets, it is not necessary to add a ruler to the image. It complicates the recording of the images, because it creates an additional source of difficulties for the illumination of the items, even though a colour-coded ruler would be helpful in verifying the colour balance.

**Special marks**

Special marks have been codified in six out of the total of 1093 recorded seizures. This represents less than 0.5% of the entire database. They are a very specific kind of data. In fact, the reproducible presence of special marks often results from production details (irregularities in punches and so on), and therefore represents a characteristic strongly related to single classes, and to some extent even to single production batches. The practical use of special marks, therefore, tends to be limited to the characterisation of particular classes of tablets having special marks in the imprint or on the borders. One (rare) example of the use of special marks in practical work occurred in the “Ferrari” class. Three types of combination of special marks were found as shown below:

<table>
<thead>
<tr>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Type A Image" /></td>
<td><img src="image2" alt="Type B Image" /></td>
<td><img src="image3" alt="Type C Image" /></td>
</tr>
</tbody>
</table>

**Characteristics**

- **Dep**: Deposit of material near the edge to the right (code D1 E1).
- **Pm**: Particular mark on the imprint.

**Characteristics**

- **Dep**: Deposit of material near the edge to the left (code B1 C1).
- **Pm**: Particular mark only slightly visible.

**Characteristics**

- **Dep**: No deposit of material near the edge.
- **Pm**: Particular marks of the imprint in three different points.

*Table IV.2.3.2.8: Example of special marks.*
These three types of special marks were found to be present in all seizures involving the “Ferrari” class. In some small seizures, it happened that one of these special mark types was not present, but whenever a more important number of tablets was seized, it was always a mixture of types A, B and C. This suggests that more than one punch is used in a given production run.

Therefore, even if marks initially had seemed to be of important value in classification, they proved to be a classical propriety that should only be considered in a second-step method. Since their observation and recording is a very simple and fast method with high information content, it has been retained for routine records.

**IV.2.3.3. Physical characteristics**

The handling of physical data describing a seizure of ecstasy tablets is fundamentally different from the description of the visual characteristics. All visual characteristics that have been described up to now give a general impression of the tablet’s appearance. If within a given seizure it is possible to clearly distinguish two sorts of tablets (for example two different colours), automatically they are split in two different subgroups. The observation of one single tablet of such a group will suffice to correctly describe the characteristics of the entire seizure, and therefore this seizure can be described as a homogeneous sample population.

The physical characteristics, to the contrary, must be measured while every single tablet of a seizure (or of a given sort of tablets) has its own numerical value. It therefore is a tablet-related measure. As previously mentioned, we aim at describing the seizure/sort of tablet as a whole, so we need to have this integral description also for the physical characteristics.

No discussion is needed about the reproducibility of the measurements themselves, as the readings were taken with simple, recognised and well-calibrated equipment, while variations between tablets usually occurred in increments large enough to avoid any risk of an ambiguous classification (such as 8, 9, or 10 mm diameter).

➢ **Weight**

For a description and comparison of the numerical data from a given sort of tablets, the following calculations were performed concerning the arithmetic average, relative standard deviation (RSD), and median with a comparable relative distance between the quartiles at 25 and 75 % (RQ).

<table>
<thead>
<tr>
<th>Average</th>
<th>Relative standard deviation</th>
<th>Median</th>
<th>Relative quartile deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( RSD = \frac{s}{Mean}.100 )</td>
<td></td>
<td>( RQ = \frac{</td>
</tr>
</tbody>
</table>

where

- \( s \): standard deviation
- \( Q75, Q25 \): quartiles at 25 and 75 %, resp.

*Table IV.2.3.3.1.: Calculation of average and median for the weight, thickness and diameter.*
In the following two examples, the assumption was made that all tablets of the seizure were produced together, and therefore come from the same production batch.

<table>
<thead>
<tr>
<th>Total number of tablets</th>
<th>129</th>
<th>Average [mg]</th>
<th>267</th>
<th>RSD [%]</th>
<th>2.6</th>
<th>Median [mg]</th>
<th>267</th>
<th>RQ [%]</th>
<th>3.53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution of tablet weight in seizure 267 (129 tablets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of tablets</td>
<td>68</td>
<td>Average [mg]</td>
<td>261</td>
<td>RSD [%]</td>
<td>2.4</td>
<td>Median [mg]</td>
<td>261</td>
<td>RQ [%]</td>
<td>3.05</td>
</tr>
<tr>
<td>Distribution of tablet weight in seizure 88 (68 tablets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table IV.2.3.3.2.: Distribution of tablet weight in seizure 267 and 88.

These two examples reflect a good description, with both descriptors (the average and the median) representing rather low relative deviations. The distribution is normal.

The same tablets were measured by two different operators (CZ and LD) in order to show the inter-operator variability of the readings and gather an idea as to the reproducibility of the measurements themselves. The results are shown below in the form of a correlation curve. As expected, this shows a very good correlation between the two operators. It is also seen that variations in the weight readings between different operators are insignificant as compared to the large variations in weight observed between tablets of different sorts.
Possible sources of variations in a given production batch are, (i) the simultaneous use of more than one punch on the same machine and (ii) changes in physical properties during the production runs. To evaluate this influence, three batches produced at the IPSC were analysed. Two batches were produced with a manual press (LotMan1 and LotMan2), a third batch was produced with an electric press (LotEl) [Kummer, 1998]. The LotEl was further divided into four different fractions of production.

<table>
<thead>
<tr>
<th></th>
<th>LotMan1</th>
<th>LotMan2</th>
<th>LotMan2 (without two outliers)</th>
<th>LotEl (all four fractions)</th>
<th>LotEl (fractions II to IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of tablets</td>
<td>30</td>
<td>50</td>
<td>48</td>
<td>129</td>
<td>89</td>
</tr>
<tr>
<td>Average [mg]</td>
<td>577</td>
<td>587</td>
<td>595</td>
<td>815</td>
<td>784</td>
</tr>
<tr>
<td>RSD [%]</td>
<td>2.9</td>
<td>7.4</td>
<td>2.5</td>
<td>7</td>
<td>2.7</td>
</tr>
<tr>
<td>Median [mg]</td>
<td>572</td>
<td>596</td>
<td>597</td>
<td>796</td>
<td>790</td>
</tr>
<tr>
<td>RQ [%]</td>
<td>2.53</td>
<td>3.19</td>
<td>3.23</td>
<td>8.17</td>
<td>3.16</td>
</tr>
</tbody>
</table>

Table IV.2.3.3.3: Variation of the weight within self-produced tablets.

This table shows what variations have to be expected when tablets are produced in an experimental way. Outliers have an important influence on the RSD but are much less important for RQ. In the presence of all fractions, both values are affected.
This representation shows that it is possible to find outliers within a given batch. A fairly large variation in weight does not necessarily mean that these tablets are from a different batch. These variations are due to inadequate quality control during production of the tablets for illegal markets.

Contrary to the illegal production of tablets, pharmaceutical industries must insure the high quality of their products. Therefore, standards for quality requirements are set [Ph. Helv. 8, 1997]. Thus, only two tablets out of 20, for instance, are allowed to be out of the following ranges in the pharmaceutical industry:

<table>
<thead>
<tr>
<th>Tablet weight</th>
<th>Limit for the standard deviation of 20 tablets [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 80 mg/tablet</td>
<td>10</td>
</tr>
<tr>
<td>&gt; 80 mg/tablet and ≤ 250 mg/tablet</td>
<td>7.5</td>
</tr>
<tr>
<td>&gt; 250 mg/tablet</td>
<td>5</td>
</tr>
</tbody>
</table>

Table IV.2.3.3.4.: Limits for the standard deviation of tablet weight.

This information shows that because of the nature of illegal production of the ecstasy tablets, it is not possible to state limits of weight variation when describing tablets coming from the same batch of production. The variation may be high because of some fraction in the batch, outliers are not uncommon in tablet production, and it must be remembered that batches having the same visual appearance may have been mixed at the source.

Some evaluation was performed in order to find an indicative limit for so-called “ideal” batches of tablets. Sixteen different types of tablets (seizures with at least 20 transmitted
samples) were used to calculate the values of RSD and RQ. In this way it was possible to describe an “ideal” batch of tablets as having RSD < 4 % and RQ < 5 %.

For some examples it was possible, after an accurate analysis of the weights within a given batch, to imagine two different subgroups with slightly different weights (in analogy to the grouping based on visual characteristics). However, seizures of this type are not subdivided further, since the batch was described in terms of the appropriate RSD and RQ values which, if necessary, can be used for comparison purposes.

![Frequency of the weight in mg/tablet over 1045 seizures (without capsules)](image)

**Figure IV.2.3.3.3.: Frequency of the weight in mg/tablet over 1045 seizures (without capsules).**

This graph shows the distribution of tablet weights over all seizures of the database (excluding capsules). This distribution is irregular. A conspicuous maximum occurs at around 90 mg/tablet, which corresponds to the so-called “Thai” tablets mainly containing methamphetamine. The other two maxima (about 250 mg/tablet and 290 mg tablet) are not associated with any special class of seizures. Quite generally, a wide range of weights occurs across the database.

**Thickness**

Measurements of thickness are treated in the same way as described for weight evaluation. The same two parameters (RSD and RQ) provide a reasonable measure for the appreciation of thickness variations within a given batch. In the following figure the same two examples are once more adduced.
One difference which has to be pointed out is the fact that the callipers measuring errors are larger (0.02 mm). The reproducibility of measurements made by different operators and at different times also shows a larger variation than that achieved with an analytical balance. This can be seen from the correlation between two operators LD and CZ who measured the same 17 tablets with the same callipers.

Table IV.23.3.5.: Distribution of tablet thickness in seizure 267 and 88.
The variations between measurements of thickness taken by two different operators are more important than those in the weight measurements. In this example, the differences of thickness readings on the same tablet were as large as 2.7 %, whereas the differences in weight were at most 0.3 %.

These differences are due to the tools used for the measurements. Two problems can arise when using metallic callipers: The readings are not simple, and illumination may influence the readings. On the other hand, the readings also require a certain amount of experience. The fact that the exact position of the tablet within the metallic callipers is not defined may be a source of difficulties.

These measurement variations might be reduced with tools, for example digital callipers or vertical callipers with a controlled pressure (force) on the object. Such tools are used in pharmaceutical quality control laboratories; they are more expensive, but they are simple and quick to use.

The following table shows once more the results of thickness measurements for the batches that were produced at our laboratory.

<table>
<thead>
<tr>
<th></th>
<th>LotMan1</th>
<th>LotMan2</th>
<th>LotMan2 (without two outliers)</th>
<th>LotEl (all four fractions)</th>
<th>LotEl (fractions II to IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of tablets</td>
<td>30</td>
<td>50</td>
<td>48</td>
<td>129</td>
<td>89</td>
</tr>
<tr>
<td>Average [mg]</td>
<td>3.81</td>
<td>3.39</td>
<td>3.42</td>
<td>3.61</td>
<td>3.53</td>
</tr>
<tr>
<td>RSD [%]</td>
<td>3.1</td>
<td>5.4</td>
<td>1.6</td>
<td>4.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Median [mg]</td>
<td>3.80</td>
<td>3.40</td>
<td>3.40</td>
<td>3.6</td>
<td>3.5</td>
</tr>
<tr>
<td>RQ [%]</td>
<td>5.26</td>
<td>0</td>
<td>0</td>
<td>5.56</td>
<td>8.57</td>
</tr>
</tbody>
</table>

Table IV.2.3.3.5.: Variation of the thickness within self-produced tablets.
It is easy to see that outliers have an important influence on the RSD value, whereas the RQ value by definition is much less influenced. When outliers are ignored (for example, by ignoring fraction I of the LotEl batch) the value of RQ increases while that of RSD decreases. This underlines the complementarity of these two values. RSD in some way is a measure of outliers, while RQ gives indications about the presence of subgroups of tablets (in this case, the substantial differences between the four fractions).

For the evaluation of thickness, no quality requirements have been reported in the literature. In analogy to the calculations made for the weight as well as for the thickness, an evaluation was undertaken to find an indicative limit for so-called “ideal” batches of tablets. The same 16 different sorts of tablets (seizures with at least 20 transmitted samples) were used to calculate the values of RSD and RQ. An “ideal” batch was found to yield thickness values with RSD < 3 % and RQ < 4 %.

Theoretically and practically, a straightforward correlation exists between the weight and the thickness of a tablet of the same batch. This supposes, however, that the density is always the same, which as shown in the case of LotEl is not guaranteed. That is why we prefer to use both measurements when analysing the same sort of tablets.

The distribution of thicknesses over all seizures in the database (with the exclusion of capsules) is given in the graph below.
This figure shows that normally the thickness of tablets is within a range between about 3 and 5 mm. A maximum is present at a thickness of about 4 mm, but there is a rather uniform frequency distribution between 3 and 5 mm thickness.

Diameter

The diameter is probably the most important physical characteristic of ecstasy tablets. In fact, because of its nature, it is a constant value directly dependent on the punch of the pressing machine. Contrary to the thickness of the tablet, this is a characteristic which the operator of the press cannot change.

Unlike the measurements of weight and thickness, the reproducibility of the tablet diameter only depends on variations due to the method of determination. Therefore, in most of the cases only one tablet diameter per seizure is measured. This is simple and quick. Variations in diameter of the same sort of tablets are always within the measuring error of 0.02 mm.

Theoretically it is possible to imagine different diameters within a given seizure, which could arise when using more than one punch (for example in rotary machines). In this period of about four years, only one such seizure was found.

The following figure gives the statistical distribution of the diameters of ecstasy tablets. Most of the tablets seized are 9 mm in diameter, a second frequency maximum occurs at 8 mm. The relatively high frequency of 6 mm tablets is due to the so-called “Thai” tablets, as shown in the discussion about the weight of tablets. Sometimes tablets of 7, 8.5, and 10 mm are also present. Other diameters are rare.
Other measurements

Among other characteristics used as standards for quality requirements fixed by the Pharmacopoeia, some measurements were made of the hardness on a number of experimental, self-made tablets [Kummer, 1998].

These measurements (see next figure) revealed very large variations within given production batches. The relative standard deviations were higher than 10 kPa. A separate analysis of the four fractions of the same production batch (LotEl I, II, III and IV) revealed a rather low variance, especially among the last three fractions.

<table>
<thead>
<tr>
<th>LotMan1</th>
<th>LotMan2</th>
<th>LotMan2 (without three outliers)</th>
<th>LotEl (all four fractions)</th>
<th>LotEl (fraction I)</th>
<th>LotEl (fraction II)</th>
<th>LotEl (fraction III)</th>
<th>LotEl (fraction IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of tablets</td>
<td>30</td>
<td>50</td>
<td>47</td>
<td>129</td>
<td>40</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Average [kPa]</td>
<td>18.26</td>
<td>18.05</td>
<td>18.91</td>
<td>5.05</td>
<td>7.08</td>
<td>3.68</td>
<td>3.48</td>
</tr>
<tr>
<td>RSD [%]</td>
<td>10.6</td>
<td>18.49</td>
<td>12.0</td>
<td>39</td>
<td>27.1</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Median [kPa]</td>
<td>18.5</td>
<td>18.9</td>
<td>19.1</td>
<td>4.9</td>
<td>6.7</td>
<td>3.7</td>
<td>3.5</td>
</tr>
<tr>
<td>RQ [%]</td>
<td>10.07</td>
<td>23.6</td>
<td>18.15</td>
<td>54.19</td>
<td>37.26</td>
<td>0</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Table IV.2.3.3.6.: Variation of hardness within self-produced batches of tablets.
The correlation graph between hardness and weight of tablets belonging to four different fractions of the same production batch is shown next. This representation demonstrates the good possibility for a differentiation of fractions based on these two physical measurements.

![Hardness versus Weight, four fractions of self-produced tablets (129 measures)](image)

Figure IV.2.3.3.8.: Hardness versus weight, four fractions of self-produced tablets (129 measures).

The hardness measurements may be of value for a detailed analysis within a given batch, but because of their poor reproducibility, this is not a first priority. In fact, it is a major disadvantage that hardness is determined by a destructive analytical method requiring a large number of tablets. This is also the main disadvantage of other physical measurements in pharmacy (friability, disintegration time in water, etc.).

Since special apparatus is required, the method is also time-consuming and expensive.

### IV.2.3.4. Chemical characteristics

- **Illegal substances, adulterants and diluants**

Gas chromatography (GC) is one of the most sensitive analytical methods for the separation and analysis of volatile organic substances. Due to its sensitivity, nanogram amounts can be analysed with high precision and accuracy. In forensic chemistry GC is often used for the analysis of substances present in illegally manufactured drugs in order to observe a characteristic profile and compare these substances in a semi-quantitative manner.

GC is a technical method requiring good training and knowledge; it is also an expensive analytical method.

For sufficiently high reproducibility of the analytical results, a calibration of the system with control samples is required prior to each analytical series, and an internal standard must be used.
Through the analysis of retention times in GC and subsequent comparison with standard mixtures, sufficient selectivity is obtained. The use of a mass-spectrometric (MS) detector largely increases the selectivity. GC-MS is one of the most powerful and selective methods for identifying compounds in mixtures. It is for this reason that it has been introduced as a routine method of first priority in ecstasy analysis.

In fact, the presence of a large number of different substances in the illegally sold tablets requires a very powerful differentiation tool and is a basic classification element. Some of these substances (as for example amphetamine and its derivatives) are so similar chemically that a simple GC (or HPLC) analysis may lead to misinterpretations. The combination of GC and MS information yields the best results.

As described before, a derivatising method (with MSTFA) was used to analyse tablet powders. This is related to the need of identifying sugars (such as lactose) which are very common diluents. It is only through derivatisation with trimethylsilyl functional groups that it is possible to identify retention times for the most common sugars. It also leads to better results for other substances with one or more hydroxyl functional groups present in prescription drugs and remedies.

A negative aspect of this derivatisation in the full chromatogram is the fact that primary and secondary amines are also derivatised by trimethylsilyl functional groups, although only partially. For example, when methamphetamine is present in the mixture two peaks appear in the chromatogram after derivatisation: one for the notderivatised and one for the derivatised amine. Sometimes even the peak of the di-tms product may be present. It is for this reason that it is impossible to measure the purity of the active substance in the same analytical step.

In the analysis of lactose, the presence of two peaks allows one to differentiate two types: Lactose-1 and Lactose-2, according to different semi-quantitative ratios between the two peaks. These results are reproducible.

**Example of Lactose (Lactose-1)**

**Example of Lactose-2**

**Table IV.2.3.4.1.: Chromatograms of seizures containing Lactose (or Lactose-1) and Lactose-2.**
The high selectivity of this method of analysis justifies its use as a first-priority method. However, it must be pointed that with GC-MS it is not possible to identify all the components in a mixture. Inorganic fractions, polymer-like substances, etc. cannot be detected. This implies that only part of the chemical composition of the ecstasy tablets is obtained.

For the purposes of providing some structure in the records of the qualitative results, the substances were divided into three main groups: illicit substances, adulterants, and diluants. Under the heading of “illicit substances”, all components controlled by legislation are recorded. They are also quantified in our ecstasy analysis system. Under the heading of “diluents”, all sugars detected are recorded, and under the heading of “adulterants”, all other components such as further active substances, precursors, medicaments etc. are listed.

In the following figure the frequency of illicit substances is shown.

![Frequency of illicit substances over 984 analysed seizures, from April 1997 to June 2000](image)

This plot shows that more than 5/6 of the seizures analysed contained illicit substances. These represent 838 different seizures. 22 different combinations of illicit substances have been codified, and over 80 % of the seizures contained MDMA, MDEA, amphetamine,
methamphetamine, or a combination of these. All other illicit substances appear rarely (in one or two seizures only). Most of these belong to the family of benzodiazepines or are a particular combination of various illicit substances.

Particular emphasis must be placed on the relatively important presence of methamphetamine tablets. This is due to the particularly large influence and aggressive marketing of so-called “Thai tablets” coming from Asia as a step into the European illicit market.

This representation does not account for the quantity of illicit substances in the tablets, although the relative area of the GC peak can give an indication as to the amount present in the tablet.

The frequency of adulterants is given in the following figure. A fundamental differentiation had to be made between seizures containing illicit substances and seizures not containing illicit substances. Adulterants are not quantified in the first-priority analysis, but a rough differentiation can be made between their presence in traces and their presence in important quantities.

![Types and frequency of adulterants in seizures with, resp. without illicit substances](image)

*Figure IV.2.3.4.2.: Types and frequency of adulterants in seizures with, resp. without illicit substances.*
First of all it has to be pointed out that 292 (approximately 30 \%) of all seizures analysed contained adulterants, which is a relatively low percentage. The distinction between seizures containing illicit substances and seizures not containing illicit substances is important. Only 21 \% of the seizures containing illicit substances showed additional adulterants, whereas 77 \% of the seizures without illicit substances contained other identified active substances. This is not surprising, since most of the seizures not containing illicit substances are prescription drugs or remedies, as shown below.

From this figure it can be seen that the most frequent adulterants of seizures containing illicit substances are caffeine and traces of caffeine (which can be combined with theophylline). These represent nearly 87 \% of these seizures. Less frequent are ephedrine and N-methyl-1-phenylethylamine. This shows that the use of adulterants in “real” ecstasy tablets is quite low, and almost deliberately restricted to caffeine. Ephedrine and other amphetamine-like substances may be added, or may be the result of improper synthesis (residual starting materials, impure substances, by-products of the synthesis, etc.).

Adulterants found in seizures not containing any illicit substance are of a high variety, and no particular substance is predominant over the others. This implies that these tablets are accidental findings, and probably cannot mislead consumers.

The high levels of acetylsalicylic acid (aspirin) and xantinol nicotinate in seizures show that many remedies and prescription drugs are sold as ecstasy tablets. On the other hand, the presence of methylthioamphetamine and N-methyl-1-phenylethylamine for example shows that illegal traffickers try to sell new amphetamine-like substances as a new product.

Finally, the following figure provides plots of the frequency of identified diluants (sugars). All tablets must have some diluant to make up the volume necessary for the production of tablets. The most frequent diluants are sugars, but other inorganic or organic substances such as talc, starch and the like which are not analysed by CG are found. Combinations of these substances are of course possible.
Surprisingly, 80% of all analysed seizures contained a sugar-like diluant, which is quite a large fraction. The frequencies of sugars in seizures containing illicit substances and in seizures not containing any illicit substance show the same tendency. The most frequent diluant is lactose, followed by sorbitol and various combinations of lactose diluants. The only interesting difference is the fact that sucrose seems to be a sugar much less used in illicitly produced ecstasy tablets than in prescription drugs and remedies.

The phosphate group can be identified in the chemical composition by using the derivative method. When it is found, this implies that calcium phosphate may be present as an additional diluant. This is a helpful factor for general comparison purposes.

Due to the different chemical nature of diluants used in pharmacy for the production of tablets, analytical methods other than gas chromatography are required. Some preliminary tests [Marquis, 2000] showed that additional information could be obtained, but also that the time factor considerably increased. The use of this analysis step as a first-priority method was not justified by the small amount of additional information gained.

It appears that the information we have at this point has sufficient discriminative power, and that it is not necessary to perform organic profiling, as is done for example in the classification of amphetamine powders in the Nordic countries. Ecstasy tablets have revealed a much larger chemical variety than amphetamine powders.

The profiling should be seen more as a second-priority analysis. It should only be carried out within a class of tablets already identified, in order to obtain supplementary separation, for example of different production batches [Lock, 1997][Gimeno et al., 2002]. Research performed on the profiling of inorganic components of ecstasy tablets [Comment, 1999] demonstrated a high potential for a secondary analysis of a restricted number of seizures.
Purity of the illicit substances

Quantitative analytical methods in chemistry usually involve complex and expensive procedures, especially when it is necessary to separate the components of a mixture of substances. In every method a calibration of the system is necessary, and often this step has to be repeated prior to each series of analyses. The use of certified standards is almost imperative.

Gas chromatography is an analytical method which is often used for this purpose, but as explained before, it was not possible to use this method for the quantitation of the illicit substance, since we used a derivatising method giving rise to multiple peaks for the target substances.

Capillary zone electrophoresis (CZE) was chosen for quantitative analysis, since it has a sensitivity and selectivity similar to that of gas chromatography; it has the advantage of a much shorter analysis time than the GC-Method used in this study. Furthermore, the preparation of samples is easier and quicker. It is a widely used and validated method.

The reproducibility of the analysis of ecstasy tablets has been evaluated elsewhere [Esseiva, 1996]. Satisfactory relative standard deviations (RSD) within 5 days were found. Three sorts of tablets gave the following results: MDEA, 1.05 % RSD; amphetamine, 1.03 % RSD; and MDMA, 1.46 % RSD. In this study the sample preparation and the analyses were carried out by the same operator using the same calibration curve. The participation in an inter-laboratory proficiency test showed that it is also a precise analytical method.

In order to check the calibration curves and to have some control over migration times and purity, a control standard was introduced for each illegal substance (MDMA, MDA, amphetamine, MDEA, and methamphetamine). These standards consisted of homogenised, real seizure samples.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Dates</th>
<th>Period [months]</th>
<th>Number of analyses</th>
<th>Purity average [%]</th>
<th>Standard deviation</th>
<th>RSD [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDMA (Sample 094)</td>
<td>07 Aug 99 to 03 Aug 01</td>
<td>24</td>
<td>76</td>
<td>28</td>
<td>2</td>
<td>7.1</td>
</tr>
<tr>
<td>MDEA (Sample 858B)</td>
<td>14 Mar 00 to 14 May 01</td>
<td>15</td>
<td>16</td>
<td>28</td>
<td>2</td>
<td>7.1</td>
</tr>
<tr>
<td>MDA (Sample 1039B)</td>
<td>03 Aug 00 to 18 May 01</td>
<td>10</td>
<td>14</td>
<td>26</td>
<td>2</td>
<td>7.7</td>
</tr>
<tr>
<td>Amphetamine (Sample 857)</td>
<td>14 Mar 00 to 02 Feb 01</td>
<td>10</td>
<td>9</td>
<td>14</td>
<td>1</td>
<td>7.6</td>
</tr>
<tr>
<td>Methamphetamine (Sample 973D)</td>
<td>03 May 00 to 18 May 01</td>
<td>12</td>
<td>16</td>
<td>23</td>
<td>2</td>
<td>8.7</td>
</tr>
</tbody>
</table>

Table IV.2.3.4.2.: Data concerning all control standards of the quantified illegal substances.

Christian Zingg, IPS Lausanne
This figure shows that over a fairly long period, the reproducibility of the control samples corresponded to about 7 to 9 % RSD. This is a higher figure than that found for the reproducibility of the analysis of a sample within a 5-day period. The measured deviations include a larger number of factors such as more operators, more than one calibration curve, different room temperatures (RT), and so on. The RSD of GC is normally < 2 % within a laboratory and < 5 % between laboratories.

The purity results obtained over a period of 2.5 years shown in the next figure reveal no particular tendency. The variation is much the same over the entire time axis, and does not depend on a particular time-related factor. The introduction of new calibration curves (13 Jan 00, 30 May 00, 09 Jun 00 and 08 Sep 00) did not influence the general distribution of the results.

More than one control-sample solution was used from time to time. In the figure shown below, the results referring to different samples are distinguished by different colours. It can be seen that this distribution is not a result of different sample preparations.

All the results obtained for control samples show that for a quantitative evaluation, a tolerance of 7 to 8 % RSD has to be accepted. Therefore, smaller differences are irrelevant in the comparison step.

As a measure of the quantity of illicit substance contained in a tablet of ecstasy, the following two indications have been chosen: the purity expressed in % of illicit substance and the content expressed in mg of illicit substance per tablet. In fact, the purity allows one to compare chemical compositions of different sorts of tablets. The content on the other hand is important with regard to toxicological analysis.

A total of 737 seizures have been analysed and quantified. The following table shows the frequency (number of seizures) versus the content of illicit substance per tablet (mg/tablet). The results are shown for the more widespread amphetamine derivatives and amphetamine itself.
Table IV.2.3.4.3: Frequency (number of seizures) versus the content of illicit substance [mg/tablet].

<table>
<thead>
<tr>
<th>mg/tablet</th>
<th>MDA</th>
<th>MDEA</th>
<th>Amphetamine</th>
<th>Methamphetamine</th>
<th>MDMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>32</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>10</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>60</td>
<td>4</td>
<td>2</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>5</td>
<td></td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>5</td>
<td></td>
<td>115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>3</td>
<td>1</td>
<td>95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>2</td>
<td></td>
<td>59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>4</td>
<td>1</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>140</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>170</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The figure shown next provides an overview of the frequency of purity for each illicit substance shown in the table above.

Figure IV.2.3.4.5: Frequency of the purity [%] of illicit substances in tablets.
When considering the purity of tablets, it is seen that for all three methoxy derivatives of amphetamine (MDMA, MDA and MDA) there is a maximum of about 30 – 35 %. For methamphetamine the maximum occurs at about 20 %; and for amphetamine the highest frequency is found for tablets with a purity of 5 to 10 %. For MDMA, purities spread from 10 to as much as 70 %, with an exceptional case containing over 90 % of MDMA, which happened to be a capsule. For methamphetamine and amphetamine, purities do not range beyond 35 %.

![Frequency of contents [mg/tablet] of illicit substances](image)

Figure IV.2.3.4.6.: Frequency of contents [mg/tablet] of illicit substances.

When taking into account the weights of the tablets in different seizures, it appears that the differences between MDMA (and MDEA) on one hand, and amphetamine and methamphetamine on the other hand are even larger (see the frequency of content). In most of the tablets containing MDMA, the content is between 80 and 100 mg/tablet, whereas for methamphetamine and amphetamine the maximum is at about 10 to 20 mg/tablet. From this figure it is quite evident that MDMA has a wider range of contents (from 40 to 170 mg/tablet) than methamphetamine and amphetamine, which have a range from 1 to 40 mg tablet. For amphetamine a second maximum is seen at about 50 mg/tablet, which corresponds to a particular class of tablets described later.

These figures reveal the very wide range of chemical compositions, which is useful in discriminating the tablets. They can also give important information about potential toxicity. Therefore, they could act as an early warning system.

It must be remembered that these content figures are the result of a very small number of analyses, often representing only one tablet per seizure. These data should be used for intelligence in priority.
IV.2.4. **Summary and direct comparison of the characteristics**

It was the aim of the first results section to show the behaviour of certain visual, physical, and chemical descriptors of ecstasy tablets in the light of a few evaluation factors (such as sensitivity, selectivity, etc.). In this first evaluation, particular emphasis was given to the frequencies of occurrence. In the following table all these characteristics are summarised schematically, in order to provide direct comparison of their evaluation and show their influence on the acquisition of information useful for classification and intelligence work.

<table>
<thead>
<tr>
<th>Summary</th>
<th>Sensitivity</th>
<th>Selectivity</th>
<th>Reproducibility</th>
<th>Simplicity</th>
<th>Costs</th>
<th>Time factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape</strong></td>
<td>+</td>
<td>++</td>
<td>NI</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Imprint</strong></td>
<td>+</td>
<td>+++</td>
<td>NI</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Scoring</strong></td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>+++</td>
<td>+</td>
<td>NI</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Photography</strong></td>
<td>+++</td>
<td>+++</td>
<td>NI</td>
<td>NI</td>
<td>NI</td>
<td>-</td>
</tr>
<tr>
<td><strong>Special marks</strong></td>
<td>+</td>
<td>+++</td>
<td>NI</td>
<td>-</td>
<td>NI</td>
<td>NI</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>+</td>
<td>++</td>
<td>NI</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Qualitative analysis</strong></td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>NI</td>
</tr>
<tr>
<td><strong>Purity, content</strong></td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

*Table IV.2.4.1.: Summary with the legend: +++ very positive, ++ positive, + slight influence, NI no influence, - negative*

In past sections, results were shown separately for each of the characteristics. At this point it is important to be reminded that the most powerful tool for classification is the combination of more than one characteristic.
IV.3. PHASE III: LINKING PROCESS AND THE INTELLIGENCE ANALYSIS METHODOLOGY

IV.3.1. Introduction

In the first two phases of the project, particular attention had been given to the analysis/classification part of the research work. Classical forensic measurements have been described and evaluated according to their reproducibility, selectivity and to the statistical distribution of results. Particular emphasis had been given to the choice of rapid analytical methods measuring highly discriminating characteristics.

The result was the creation of an organised collection (database) of valuable data concerning a large number of ecstasy seizures. This represents a rich basic source of information concerning ecstasy tablets, and is the result of the first step of the intelligence process, viz., the collection and organisation of the data. The systematic routine recording of new ecstasy tablet seizures according to the methods described will yield an efficient data set for subsequent intelligence analysis. This should not exclude at all the collection of further forensic data of particular seizures which could improve the analysis (for example, information about wrappings and so on).

As a logical consequence of the work described above, it has recently been decided to organise the data collection (updating of the database) as a monthly routine in the police work in Lausanne (IPSC) and Zurich (WD).

The present Phase III section describes the extraction of latent information contained in the database. It constitutes the switch from the collection of data to the analytical part of the intelligence process. It begins with some explanations about the extraction of general information representing more strategic intelligence. Then it proceeds to the more tactical intelligence work, defining the entities and links used for the creation of subgroups and classes and their subsequent integration in the intelligence process.

IV.3.2. Getting general information from single characteristics

A classical strategic use of the collected data is that of analysing one parameter over a certain period of time throughout all recorded seizures. Analysing, for example, the colour of tablets in this time perspective, it was seen that over the last three years the use of dyes has fundamentally increased. This would lead to the conclusion that it is necessary to have a better look at the dyes market in order to filter out interesting drug-related actors. This use of information is usually called the intelligence-guided policing [Ribaux, 2003]. Gathering strategic intelligence of this kind strongly depends (or relies) on the initial questions and hypotheses.

The most frequent general information request concerns manufacturing activities. Interpreting single parameters of a seizure or of a group of seizures can lead to some general intelligence about the source.
Generally, the visual description of ecstasy tablets provides a clear link to the source, that is, to the underground tableting laboratory. Exactly as in the legal private economy, the producer of ecstasy tablets has an interest to sell a product with good reputation. Therefore, he must produce tablets which are recognisable by the consumer as the “good ones”. In this context, imprints are an important factor. From a forensic point of view, on the other hand, the imprints help linking seized tablets to a possible common illegal tableting source.

However, in the illegal production of ecstasy tablets a good and trendy tablet imprint, for example, is very likely to be copied by other producers, and will therefore appear in another illegal trafficking network. A good example of this imitation activity of manufacturers is the case of “Mitsubishi” ecstasy tablets. For these, 78 seizures have been recorded among the total of 1093 seizures. Within these seizures at least five different, visually differentiable types of “Mitsubishi” imprints and tablet shapes were found in different periods and also simultaneously. A similar situation was observed over a period of five years in Europe by EUROPOL, who distinguished 28 different types [EUROPOL, 2000]. Similar imitations were found for the “sparrow” imprint, which was present over a long time in rather different forms.

Among visual characteristics, the imprint represents the most valuable indicator of manufacturing activities. It is the “trademark” par excellence. A second characteristic that can serve as a search criterion is the description of colour, especially when it is not white or grey. A third characteristic is tablet shape, which constitutes useful information when no imprint is present on the tablets.

Among the three physical measurements of weight, thickness and diameter, particular value attaches to the diameter. The variations in thickness and weight within tablets of the same batch were much larger than those in diameter. This is not astonishing, since the diameter is given by the dimensions of the hole in the die of the tableting machine. This is a fixed metallic part of the machine which never will be changed by the operator himself, except when punches and dies are replaced. The thickness, and therefore also the weight of a tablet, to the contrary, can vary as a result of adjustments made by an operator, even during the tableting process. From a forensic point of view, this implies that the diameter, much more than weight and thickness, provides important leads as to places of (common) manufacture.

The statistical calculations concerning the variations in thickness and weight are more often used in a second step during the classification, in order to give an idea of the entire class and provide criteria for deciding whether one has to do with a common batch or not. The relation between diameter and thickness can provide some indication as to the manufacturing habits of an underground chemist.

The chemical analysis of the tablets, and particularly the qualitative results, provide additional important indications as to habits of the manufacturer. In this case one must distinguish between the interpretation of the general composition (illegal substance and cutting agents), which yields intelligence about the tablet producer, and the purity profiles of the illegal substance, which may be attributable to other chemical laboratories acting as suppliers of underground tableting laboratories.

For instance, the combination of MDA (which is no longer very common in the illegal market) with caffeine and ephedrine gave information about one clandestine laboratory producing a particular type of tablets (with imprints of diamonds, lightning arrows, and the letter “R”).
We can affirm in conclusion that for strategic intelligence purposes, the three main characteristics of imprint description, diameter and qualitative composition in an ecstasy seizure constitute good links to the manufacturing activity. It must also be admitted, on the other hand, that strategic intelligence gathered from available data is largely restricted to the recognition of market trends.

The integration of additional investigative parameters (persons involved, etc.) could sensibly increase the strategic value. In this way it is possible to get information for example about the number of involved players in the market, or to distinguish between producers and traffic of counterfeits, and so on. This combination could also give additional knowledge about traffic ways (importers, dealers, consumers, …) and their role in the whole business.

IV.3.3. The description of entities

The entities discovered and used for further work were divided into three types: entities related to the structure of the data, entities related to the classification, and entities related to the pure analytical step. The icons used in the following table were used in the IBase™ interface and in the Analyst’s Notebook™ applications.

<table>
<thead>
<tr>
<th>Entity</th>
<th>Symbol</th>
<th>Concerning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sort</strong></td>
<td>![Symbol]</td>
<td>Separately expressed only when, within a given seizure, two or more different sorts of tablets are present.</td>
</tr>
<tr>
<td><strong>Seizure</strong></td>
<td>![Symbol]</td>
<td>Main structure entity. It gives the summary of all basic forensic information (visual, physical and chemical).</td>
</tr>
<tr>
<td><strong>Case</strong></td>
<td>![Symbol]</td>
<td>Entity expressing administrative and certain pieces of inquiry-related information.</td>
</tr>
<tr>
<td><strong>Subgroup</strong></td>
<td>![Symbol]</td>
<td>Main classification entity. Created when high similarity was detected between two or more seizures.</td>
</tr>
<tr>
<td><strong>Class</strong></td>
<td>![Symbol]</td>
<td>Created to group subgroups and seizures bearing some similarities, or appearing related because of other features (occurrence, other case-related seizures, etc.).</td>
</tr>
<tr>
<td><strong>Pointer</strong></td>
<td>![Symbol]</td>
<td>Virtual entity necessary to group all the other entities according to similarities and other characteristics for a restricted time during the analysis step.</td>
</tr>
</tbody>
</table>

Table IV.3.3.1: The description of entities (definition of similarity in chapter 3.4.1.).

According to the most frequent operational analysis of data, the most important entity is seizure. It constitutes the main entry in the original Filemaker Pro 4.1™ database. Seizures most often only comprise one sort of tablets, and only in exceptional seizures will it be necessary to make a subdivision into sorts of tablets. Later on, a distinction between seizure and sorts of tablets will only be made when necessary; elsewhere the term “seizure” is used.

Single tablets were not described as an entity. In fact, their separate comparison may be interesting from a judicial point of view, but has nearly no influence on the more general classification step. It is not interesting to know whether one single tablet of a seizure is
particularly similar to one tablet in another seizure. Sometimes data (especially data for weight and thickness) for single tablets have been compared within a subgroup of a given seizure with the aim of obtaining a general statistical overview, but not with any classification aim.

The second structural entity is the case, which includes the temporal (date of seizure) and the geographic (place of seizure) information. It includes the overview of seizures (how many seizures of different tablets were found) and the link to the inquiry.

The class entity and the subgroup entity are the result of grouping, mainly according to the observation of similarities between seizures.

A subgroup is created when two or more seizures show similarities in all or nearly all collected and available characteristics. The subgroup is then characterised by the summary of descriptive parameters. For the description of subgroups, fantasy names were invented, analogous to police services giving an operation name to certain special inquiries.

A class is created instead when two or more subgroups and/or single seizures are similar, only in a restricted number of characteristics. Subgroups within a given class have one or few common, clearly distinctive characteristics, while the sum of all other characteristics (as for example colour, imprint, etc.) supports a common source production site. Classes are described by their own parameters. Linking parameters other than those relating to the visual, physical and chemical description could be grouped within a class (for example, the systematic simultaneous presence of two different types of tablets).

The pointer is mainly a virtual entity, which allows visualising and creating groups of seizures having at least one similar parameter. At the end of an analysis step it normally transforms to a class or a subgroup, or it disappears.

The whole process is never rigid and is constantly revised by interaction.

**IV.3.4. Creating subgroups and classes of seizures**

**IV.3.4.1. Similarity and similarity levels**

The classification of seizures turned out to be the most frequent and important task when working with the database described. Two different starting questions appeared to produce the same output, viz., the creation of a subgroup or the creation of a class of seizures.

One of these questions was the “bottom-up” question: A new seizure is to be compared with existing subgroups (and classes) or with all other seizures in order to create a new subgroup.

The other, less frequent question was the “top-down” question: The entire population of recorded seizures was screened for one or a combination of special characteristics in order to extract a restricted group of seizures, which was then analysed more closely.

While starting from these two different points of departure, the result was always the same, viz., that of obtaining a subgroup or a class of seizures. For this task it was necessary to get a similarity indicator between seizures and, in a later phase, between different subgroups.
Translated to a mathematical language, the problem of similarity is that of calculating a
distance between two objects, which is well known and well described in the case of
numerical data but constitutes a more complex problem in the case of alphanumerical and
textual data. Sometimes such distances are expressed in terms of a similarity coefficient.
Some methods used when comparing chromatograms have been described in the theoretical
part (Section II.1.3). Other suitable methods are known in spectrometry.

Thus, for most of the characteristics of ecstasy tablets described above, a simple numerical
difference between two numbers appeared to be satisfactory. More problematic is the
evaluation of a distance in the case of text or alphanumerical characteristics. An example:
knowing of three different seizures with white, grey and red tablets, it seems natural to
assume that the white and grey tablets are “more similar” than the white and red ones. This
example shows that even in the evaluation of text and alphanumerical characteristics, distance
estimates are sometimes feasible.

The limits and variations of measured data have an important influence on the calculation
of distances and on the interpretation of these similarity values. It is important to recognise
that it is theoretically and practically impossible to interpret distances smaller than the data
variation or below the detection limit of the method. An example: assume that there were
three seizures with the average diameters of (A) 8.08 mm, (B) 8.09 mm and (C) 8.06 mm.
Even if the distances are 0.01 and 0.02 mm, it is not possible to say that seizures A and B are
closer than seizures A and C, since the measuring error is 0.02 mm, which also corresponds
to the variations within a seizure.

In the case of weight and thickness, two values were adopted as criteria for attribution to a
given production batch: the values of RSD and RQ. Limits have been defined (see above) to
delimit so-called “ideal” batches.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSD [%]</td>
<td>&lt; 4</td>
</tr>
<tr>
<td></td>
<td>&lt; 3</td>
</tr>
<tr>
<td>RQ [%]</td>
<td>&lt; 5</td>
</tr>
<tr>
<td></td>
<td>&lt; 4</td>
</tr>
</tbody>
</table>

Table IV.3.4.1.1.: Limits of so-called “ideal” batches.

In all other characteristics, the similarity had to be evaluated more particularly in relation
to its frequency of appearance. The comparison of a set of characteristics proved to be much
more efficient than the evaluation of any single parameter.

While similarities between two objects can be any value on a continuous scale, it proved to
be necessary to define a few distinct similarity levels. From purely a classification point of
view, the creation of such discrete levels allowed new entities (classes and subgroups) to be
created or rejected in a rapid way.

In the following table, a subdivision is offered in order to provide a standardised base for
simple information transmission. It is necessary to recognize that these levels are not entirely
independent. In fact, there exists an interconnection and continuity between them. The
subdivision, however, yields a tool for easy exchange of information, inasmuch as certain
values can then be assigned to the different classes and subgroups of ecstasy tablet seizures.
<table>
<thead>
<tr>
<th>Description</th>
<th>Example</th>
<th>Interest</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>No similarities</td>
<td>Completely different sort of tablets.</td>
<td>Strategic</td>
<td></td>
</tr>
<tr>
<td>Similar characteristics</td>
<td>Two or more seizures have one (or a few) common characteristics.</td>
<td>Strategic</td>
<td></td>
</tr>
<tr>
<td>Similar TYPE</td>
<td>Between two or more seizures, all (or nearly all) physical or chemical characteristics are similar. These seizures are, therefore, of a similar physical or chemical type.</td>
<td>Strategic/Tactical</td>
<td>Classes</td>
</tr>
<tr>
<td>Similar KIND</td>
<td>Two or more seizures have all (or nearly all) chemical and physical characteristics in common. Tablets belonging to the seizure are of the same kind.</td>
<td>Tactical</td>
<td>Classes/Subgroups</td>
</tr>
<tr>
<td>Similar batch</td>
<td>All chemical, physical and any additional information is indistinguishable by first-priority analytical methods.</td>
<td>Tactical</td>
<td>Subgroups</td>
</tr>
<tr>
<td>Same batch</td>
<td>According to second-priority analytical methods such as chemical impurity profiling or other special physical marks, two seizures cannot be differentiated and lead an expert to conclude that they belong to a common initial batch.</td>
<td>Reporting</td>
<td></td>
</tr>
</tbody>
</table>

*Table IV.3.4.1.2: Standardised base for simple information transmission.*

Using this table as a tool, it was possible to easily attribute a new seizure to an existing subgroup or class, to create a new subgroup or class of seizures, or to integrate it as a nonclassified seizure.
IV.3.4.2. **The intuitive way**

The intuitive way is mainly a step-by-step search according to a restricted number of characteristics. This means that in a first step the analyst intuitively (according to his or her knowledge of trends and statistical frequencies within the database described before) chooses one particular, rare and typical characteristic. Sometimes the simultaneous presence of two or three such characteristics may be of a particular importance or combining power. Within a smaller set of seizures, an additional characteristic can then be selected in order to find an even smaller set of class candidates.

This process of narrowing down will go on until a sufficiently restricted number of candidates has been found. Then the entire set of characteristics that have been measured and described is subjected to one-by-one comparison. In cases where the set of candidates found has already been described as a subgroup of a particular sort of tablets, the new seizure is compared with the class description set of characteristics.

The step-by-step method is particularly efficient when using independent characteristics. Experience shows that the application of only two or three consecutive steps already gives rather useful candidates.

The choice of adequate parameters mainly depends on the frequency of the recorded characteristics. It normally starts with the most discriminating characteristic. It is important to recognise that the discriminative faculty of a characteristic strongly depends on the set of candidates. This means that once a new set of seizures has been found a new evaluation of the frequency of a further characteristic has to be made. It is possible to make this evaluation visually if the first search step is very efficient and reduces the set to a reasonable number of candidates. In most of the ecstasy tablets seized, the imprint is such a discriminating characteristic. That is the reason why the intuitive way generally turns out to be the most efficient and quickest method in the classification process.

Searches performed in this manner have to be more or less tolerant to normal variations, error limits and outliers. It is important, for example, to be able to search for a range of diameters rather than for a precisely fixed diameter. Therefore, the database software *Filemaker Pro 4.1™* turned out to be very efficient, both for numerical and for nonnumerical data. On the other hand, the same *Filemaker Pro 4.1™* software was found not to be appropriate for a continued step-by-step search proceeding from a set further down to a subset. Instead, a search with additional restricting parameters will have to be performed on the database.

In this perspective a proposition for further work could be the evaluation of a database, where it is possible to precede form a set down to a subset, always being able to make geographical and temporal analysis, before setting a definitive class or subgroup of seizures.
An example for this kind of classification method is shown below. The following seizure has been introduced in the data base:

*Figure IV.3.4.2.1*: Example of seizure 682.

**Step 1**

The first search action is performed with the imprint description *(moineau)*. This gives a rather large set of 36 different seizures out of the total of 1093 seizures.

**Step 2**

Within this set of seizures, different shapes of tablets exist. Therefore, in the next search the shape code *RBB* is added. This then yields a set of 15 seizures.

**Step 3**

The following search includes the restriction to the illicit substance *MDEA*, which yields a final set of seven candidates.
Figure IV.3.4.2.2.: Example of a list of candidates.

**Step 4**
A closer look at the seven candidates shows that seizure Z51 can be discarded, since the diameter is different, and seizure 974G can be discarded, since it has no breakline and a different thickness.

**Step 5**
After a closer evaluation of all other characteristics, the present seizure could be included into the subgroup “Port028” containing a total of five seizures, all coming from Zurich.

This is an example of a rather simple classification of seizures. Of course, other more complicated examples may appear, but the principle of the so-called “intuitive way” of classifying remains the same.

This way of creating new entities has the great advantage of being very quick and efficient, especially in view of the fact that ecstasy tablets have highly variable characteristics or combinations of characteristics (such as imprints) and combinations of highly independent characteristics. Its main disadvantage resides in the fact that the operator has to have a perception of the major discriminating characteristics, which is quite easy when he is dealing periodically with seized ecstasy tablets, but much more difficult when he is dealing only occasionally with samples of this kind. On the other hand, the use of frequency graphs of appearance as illustrated in earlier sections quickly gives a good idea of the situation.
Accordingly, it was decided that the intuitive method be the method of choice for our purposes.

**IV.3.4.3. The use of metrical methods**

In analogy to the method that had earlier been described as “quotient method” (Section II.1.3.3), a similar application has now been developed and tested. The new method tested is a one-step method where the complete set of recorded characteristics of a new seizure of tablets is compared one to one with all seizures in the database.

Toward this aim, the set of characteristics of a new ecstasy seizure was described with a 15-variable vector.

\[
\begin{bmatrix}
    x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}
\end{bmatrix}
\]

where

- \( x_1 \): Imprint description
- \( x_2 \): Breaklines alphabetical code
- \( x_3 \): Colour alphabetical code
- \( x_4 \): Tablet shape code 1 alphabetical code
- \( x_5 \): Tablet shape code 2 alphabetical code
- \( x_6 \): Tablet shape code 3 alphabetical code
- \( x_7 \): Weight real number
- \( x_8 \): Diameter real number
- \( x_9 \): Thickness real number
- \( x_{10} \): Illegal substance alphabetical code
- \( x_{11} \): Purity of first illicit substance real number
- \( x_{12} \): Purity of second illicit substance real number
- \( x_{13} \): Purity of third illicit substance real number
- \( x_{14} \): Adulterants text
- \( x_{15} \): Diluants text

As described in the theoretical part in connection with the quotient method, a quotient was calculated on the basis of identical factors in the two vectors being compared. In the case of numerical factors (such as weight and diameter) this was a simple calculation. For alphabetical codes another system had to be found. It was decided to treat text factors similarly to Boolean variables, attributing a value of 1 when the textual combination matched, and a value of 0 when it did not match (or in the absence of a value). Incomplete data files were used without any further adjustment.

In the resulting matrix \( R_{ik} \), the maximum number \( N \) of \( r_{ik} \) per line which had a value lower than a preset \( r_{max} \) was found and recorded as described in the theoretical part. A minimum number of \( N_{min} \) was arbitrarily set in order to screen a certain number of seizures.

For the test, a set of 95 sorts of tablets belonging to a known number of subgroups, all more or less similar, was chosen and compared by an automatic comparison process in the Excel 97™ software. All seizures had already been classified, so it was possible to control the efficiency of this method by checking the rate of retrieval defined as the ratio between the
number of seizures found as belonging to the given class of seizures, and the number of class members actually present.

The two graphs shown next illustrate the influence of $r_{\text{max}}$ and $N_{\text{min}}$ in the specific case of a seizure belonging to the subgroup “RAABleu”. This class comprises 12 different seizures.

![Graphs illustrating the influence of $r_{\text{max}}$ and $N_{\text{min}}$](image)

*Figure IV.3.4.3.1.*: Comparison of seizure Z25F with members of class RAABleu as a function of $N_{\text{min}}$ and $r_{\text{max}}$.

From these two graphs it can be seen that all seizures of the subgroup “RAABleu” were always retrieved among the candidates selected. However, when the minimum number of characteristics $N_{\text{min}}$ was set to 10, one member of the subgroup “RAABleu” was no longer present among the set of candidates (false negative). It was also seen that the number of candidates rapidly increased from 13 to 40 cases when $N_{\text{min}}$ was made smaller. Increasing $r_{\text{max}}$ (the limit of variance between the same characteristic of two seizures) produced a less obvious increase in the number of candidates.

In this case the quotient method proved to be very efficient. In fact, all members of the class are found within the total set of 95 seizures. These results suggest that one should work with low $N_{\text{min}}$ levels, and instead vary the $r_{\text{max}}$ level. Other examples showed that setting $r_{\text{max}}$ at a very low level (0.5) not always had the effect of retrieving all seizures of a subgroup among the candidates.

The graph reproduced next shows the results for seizure 836A, which is a member of the subgroup “Superman2B” belonging to the class of “Superman2” (example shown below).
In this representation one can see that even by reducing $r_{\text{max}}$ to a minimum, it is impossible to exceed a retrieval efficiency of about 25%. In fact, “Superman2B” is a subgroup of the Superman2 class. Since the differentiation among these tablets is made on the basis of just one slight, though significant difference in thickness, it turns out that the quotient method is only efficient for a general classification. No candidates of the subgroup were excluded from the final candidates. The “Superman2” class counts nine members, which were always present in the final list of candidates.

These few experiments showed that the quotient method could be an efficient tool for classifying ecstasy tablet seizures. It is a valuable method even when some characteristics are absent, which means that it is possible to deal with an incomplete data set. The results also show that limits have to be changed according to the sort of tablets involved. It also turns out that a second step is necessary. In fact, it is necessary to manually evaluate all candidates proposed. As it stands, it is a time-consuming methodology as compared to the intuitive method.

Since it did not produce an increased level of discrimination, the quotient method was not used in preference to the intuitive way. It must be pointed out, however, that this method could be developed as a tool for less experienced analysts. In our tests, all variables were taken as equivalent, but the introduction of weighting factors accounting for the importance of given characteristics could improve the applicability of this method.

Thus, the quotient method is useful. It is less sensitive than the intuitive method but would be a good tool for workers with little experience in this field.
IV.3.5. **The definition of links and their properties**

Having created new entities (of subgroups and classes) according to a similarity evaluation of seizures, it will be important now to define the linking possibilities offered by our system.

In a general way, linking people, objects, and criminal events represents the fundament on which to reconstruct a history or a criminal action. Based on these three elements, one can distinguish three basic types of link: (1) a **human relation link** existing for example between father and son or between two friends; (2) a **similarity link** observed, for example, between two objects having one or more than one similar characteristic, and (3) an **action relation link** created through a particular action between two objects/persons.

Forensic science includes all three types of link. By DNA analysis it is possible to find family relations between human beings. By comparing chemical, physical and other characteristics it is possible to link two different objects. The interpretation of this link may indicate a common source of the objects. An example of an action relation link are the traces left by a burglar using a tool to open a door. Here one has to do with form traces rather than with substance traces; they can be linked with another action.

The following list of links has been used in relation to the existing dataset and to the possible forensic intelligence output.

- \( L(s, \text{sub}) \) **The link between a seizure and a subgroup**
  
  **Similarity link type.** This link only exists when most of the characteristics of the seizure are included in the descriptive parameters of the subgroup.

- \( L(\text{sub}, \text{cl}) \) **The link between a subgroup and a class**
  
  **Similarity link type.** A link exists when the descriptive parameters of the class include at least a few descriptive parameters of the subgroup. The set of seizures of one subgroup is then of a type (physical or chemical) similar to that of the seizures of the other subgroup.

  **Action relation link.** A link between a subgroup and a class is also possible when other factors suggest a common source of manufacture or of trafficking. For example, it could be that in seizures, regularly two different sorts of tablets are found. The two sorts of tablets belong to different subgroups (according to their characteristics), but as they always appear as “twins”, the two subgroups are linked to the same class.

- \( L(s, \text{cl}) \) **The link between a seizure and a class**
  
  This is the same as for the link of a subgroup with a class, with the difference that only one seizure has been recorded (and therefore does not belong to a subgroup).

The relation between a seizure and a case is a fixed data from the inquiry and it is merely a result of data organisation. It is not subject to any interpretation, as it may or may not exist, or a seizure may or may not have been recorded within this case.

It is important to recognise that every single seizure must be, and is, part of one and only one case, while on the other hand every case can have one or more seizures. Cases without
any seizure are theoretically possible, but have never been introduced, since the database comprises seized ecstasy tablets rather than tablets imagined or heard about.

For further interpretation, it is essential to recognise that, when a seizure is linked to a particular subgroup, indirectly the case is linked to the subgroup as well.

All links described are symmetrical, which means that the link between a seizure and a subgroup \([L(s, \text{sub})]\) is equivalent to the link between a subgroup and a seizure \([L(\text{sub}, s)]\).

**IV.3.6. Interpretation and analysis of the links**

**IV.3.6.1. Introduction**

Once seizures and cases have been recorded, subgroups and classes of seizures have been created, and similarity links between seizures and subgroups have been established, a good data set is available for further analysis. The analysis of a particular subgroup or a class of seizures typically gives intelligence on a tactical and operational level.

Three main analysis steps have been used to give further intelligence and to increase perception of a subgroup, a class of seizures, or a whole market. These three steps are

1. The temporal analysis.
2. The geographical analysis.
3. The linking network.

Does the sample contain a controlled substance? What is its purity/quantity? These are the “traditional” questions in illicit product analysis, mostly asked by courts for a judicial purpose. They are of nearly no interest for the inquiry.

Even if it is necessary to keep in mind the restricted elements of an inquiry (basically only the date and the place of seizure) at our disposal, it is possible to provide further intelligence to the inquiry agencies.

On a temporal level it is normally possible to answer questions such as: When and where has this kind of tablets appeared for the first time? How long was it present in the illegal market? Has an interruption of its availability been noticed? Answering these questions it is possible to focus on the time of importing tablets to a region, to check efficiency of police operations, or to notice absence of particularly important dealers (for example when in prison, …), and so on.

On a geographical level, questions to be answered are: Where did this kind of tablets appear for the first time? Is there a concentration of seizures somewhere? Has there been a change of place over time? Answering these questions it is possible to focus on the regional head of illegal organisations, or to coordinate more efficient and targeted border controls, and so on.

On a linking network level, finally, questions like these can be asked: Are there other kinds of tablets which regularly appear in connection with these tablet types? Is it possible to find particular seizures apparently taking up a central position in the network? What seizures are linked?
Answers to these questions can be expected from the analysis of our dataset in an operational and tactical intelligence perspective. It is worth repeating that this kind of information is needed rapidly for inquiring purposes. Its tolerance to the confidence interval is higher than in judicial cases, as it has to be used as an indication of evidence, like any other information found during the inquiry.

**IV.3.6.2. The temporal analysis**

The handling of a huge number of data is difficult and complicated. It is advantageous, therefore, to use a restricted set of items for analysis, as for example a subgroup or a class of seizures.

Unfortunately, the software used for our database did not allow creating an online set of entities for further analysis. The creation of online sets of items is a typical advantage of the IBase™ database system used, precisely, for general criminal analysis.

The simplest way to bypass this problem was obtaining an extract from the Filemaker Pro 4.1™ data system containing a subgroup of seizures or other entities. This may be regarded as a screening or filtering action, which has the major disadvantage that in later updates it must be manually performed, since the data are not directly linked to the database. To facilitate this action from a practical point of view, a file has been created in which all information about the subgroups and classes created was assembled. Therefore, when a new seizure was found to belong to an existing subgroup, the data were added directly to this kind of file.

From a technical point of view, the temporal analysis was performed with the I2 Analyst’s Case Notebook™. The preparation of the dataset followed the itinerary reproduced below, by passing through an Excel 97™ datasheet.

![Figure IV.3.6.2.1: Itinerary for the preparation of the Case-Notebook dataset.](image)

The I2 Analyst’s Case Notebook™ allows one to create self-made templates as a suitable interface for the importation of organised data from the Excel 97™ datasheet. An importation template definition is shown in the following example:
Figure IV.3.6.2.2: Example of importation template.

Within the I2 Analyst’s Case Notebook™, the handling of entities is quite easy and convenient. Adding and taking away entities is a simple and rapid operation.

An example of a temporal representation of seizures made via the I2 Analyst’s Case Notebook™ is shown below.

Figure IV.3.6.2.3: Example of temporal representation of two subgroups.
This representation shows the temporal distribution (x-axis) of seizures represented according to special characteristics (colour, class, subgroup, imprints, etc.) on different y-axes. In the example above two different subgroups (characterised by the imprints “KFC” and Mc Donalds”) are shown on two axes simultaneously. So it is possible to see that the seizure 156B and 122A have been made in the same period. On the other hand seizure 342 has been made approximately two months after seizure 098. This is a standard output of this software. In this case the x-axis is divided into months, but it is also possible to provide a scale of days or years.

The main standard intelligence that can be extracted from this kind of representation is the date of the first and, perhaps, the last seizure in a subgroup, for example. This provides some indication as to the time of presence in the illegal market. The temporal analysis also may reveal periods where seizures of the same kind of tablets were made more frequently. This may be interpreted in terms of a higher police activity or of a higher dealer activity.

According to this information and particularly in combination with other data coming from the investigation it is therefore possible to make concrete hypothesis concerning this special traffic organisation, for example to define the period or even the date of arrival in the country of a batch or to identify the date of the end of a particular traffic, for example because of a particular important police operation.

As will be shown later in the “Superman” class of seizures, in one case of the Canton of Neuchâtel (entry 974), 49 tablets of 21 different types of tablets were seized in an apartment. This happened in January 2000. Many of these tablet types could be linked to existing subgroups. However, the temporal analysis quickly showed that most of them were old subgroups last seized a long time ago. For example, one tablet with a superman imprint was found to be linked with a subgroup (“SupermanPEA”) that had disappeared from the illegal market in 1995, that is, five years earlier. The additional intelligence which has been gathered in this case was that this case represented a collection of ecstasy samples that had been started at least as early as 1995. Regardless of whether the person concerned is suspected to be a consumer or a dealer, one can affirm that a connection to the ecstasy market already existed for at least five years. The “traditional” analysis of this case would have shown that 49 tablets containing an illegal substance have been seized (this is not considered a serious case by court decision).

IV.3.6.3. The geographical analysis

The geographical evaluation of seizures was not a priority in this study. In fact, the data concerning geographical indications in relation to the seizure were limited to the name of the city or village where the seizure occurred.

Where necessary, the geographical information was integrated into the data listing of seizures or into the link charts, as shown in the following example:
In this case the two seizures coming from the Canton of Ticino are shown in red. This representation shows that seizures of this subgroup were made first in Zurich, and only later in the regional market in the Canton of Ticino. Both seizures occurred in the same region of Locarno. The typical intelligence that could in this case be provided to the police authorities of the Canton of Ticino is the fact that there could be a supplier related somehow to Zurich, and that a closer comparison of inquiry data of the two seizures made in Locarno could give additional intelligence.

Two major possibilities for improving the geographical analysis of available seizures can be identified. Within a larger city such as Zurich, it would be interesting to get some more detailed information about the actual place of seizure. This could be achieved by indicating the street within the city, or at least the city quarter or a particular discotheque. An analogous analysis of ecstasy seizures within such a small region could give additional intelligence to the inquiry agencies.

A second improvement could be conceived in the adaptation of automatic mapping systems such as those used in the analysis of burglaries [Ribaux, 1997]. The use of maps (Swiss, Cantonal, and city maps) could help localise seizures in a better way. Of course, the most efficient way would be using online integrated systems of geographical mapping.

IV.3.6.4. The linking network and the IBase™ interface

Once subgroups and classes of seizures have been created and analysed from a temporal and geographical point of view, it will often be of interest to get more information about their “connection” with other subgroups and classes, particularly about the so-called action links to other seizures and subgroups.
For restricted sets of seizures it is possible to proceed as in the case of temporal analysis, importing the necessary data to the link-visualisation software I2 Analyst’s Link Notebook™, as shown below.

Figure IV.3.6.4.1.: Itinerary for the preparation of the Link-Notebook dataset.

The main disadvantage of this procedure is again the screening step. Even more than in temporal analysis, this has a negative influence on the analysis. In fact, very often in this step of the analysis, we are interested in expanding our representations to visualise new seizures belonging to other subgroups or classes.

More efficient network analysis can be done using an IBase™ interface for the database. The essential advantage of this interface database is its compatibility with the Analyst’s Notebook™ tools. Practically, this allows one to work in the visualised Graph and obtain any information needed, from the IBase™ database. Secondly, this tool allows one to expand an existing Graph of linked cases and seizures with other links to seizures, cases and subgroups not yet shown.

The basic entities of the IBase™ interface have been listed earlier. In addition, links were visualised in the following manner.

<table>
<thead>
<tr>
<th>Link</th>
<th>Colour</th>
<th>Concerning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>ExistingLink</td>
<td>Black</td>
</tr>
<tr>
<td>Classification</td>
<td>ClassificationLink</td>
<td>Red</td>
</tr>
<tr>
<td>Analysis</td>
<td>PointerLink</td>
<td>Blue and others</td>
</tr>
</tbody>
</table>

Table IV.3.6.4.1.: Description of the visualisation of links.
The structure of the IBase™ interface as it appears on the screen is shown below.

![Image of the IBase™ interface](image)

**Figure IV.3.6.4.2.: Structure of the IBase™ interface.**

The IBase™ interface was created with simple, basic knowledge of computing. All entities with their numerical and textual data of the original Filemaker Pro 4.1™ database were imported quickly and completely to the interface. In the same way, existing links between seizures, subgroups and classes were automatically introduced to the interface. Once entities and links are imported to the IBase™ interface, the system is ready to perform link network analysis over the entire dataset.

The main disadvantage of the IBase™ software is its inability to accept sophisticated queries within the dataset. It appeared particularly difficult to make queries according to numerical data. For example, it was impossible to look for all tablets having diameters between 9 and 9.3 mm. Instead, it is possible to find within the dataset one particular word or sequence of signs, such as the internal number. This was the main reason why it was decided to leave the principal database of ecstasy seizures in the original Filemaker Pro 4.1™ database. The IBase™ system would not properly admit any photographs, while Filemaker Pro 4.1™ does.

**Examples of linking network analysis**

The visualisation of a subgroup with its linked entities may result in the following disorganised representation. This is the result of expanding the subgroup “RAABleu” over three levels, including connecting links and common neighbours.
In the centre of the red star of lines one sees the entity representing the “RAABleu” subgroup. To organise this raw figure, the standard I2 Analyst’s Link Notebook™ proposes four different layout charts (the peacock layout, the hierarchy layout, the grouped layout and the circular layout). These different layouts are not shown here, since they did not give useful results; they were not used.

Instead, the manual analysis of the link network proved to be more efficient. For a more distinct representation of the given subgroups, it appeared practical to isolate the subgroup entities, and particularly the one analysed, in this case the “RAABleu” entity. After that, cases and the related seizures are organised so as to be at a small distance. The systematic positioning on one line of seizures belonging to the same subgroup, and subsequent alignment of the related cases is a useful first step. Then other related seizures are reorganised on a third line, in order to enable a representation of further links to other subgroups in the lower part of the visualisation graph. As a result, the upper part of the link chart shows the subgroup relations (in this case of the “RAABleu” subgroup), the lower part of the chart shows other links that can be interpreted. This representation was named the “grape” chart, and is shown below.
This figure shows the 10 seizures of the “RAABleu” subgroup on the first red line. Seizures indicated in light blue are grouped by a pointer on the left-hand side; seizures in darker blue are grouped on the right-hand side of the chart. It can be seen that in one case the two were grouped together. The figure shows that three of the cases involved included several different seizures each. Three cases (9007, 5193/98 and 881/98) each included more than one seizure of the same type (seizures belonging to the same subgroup) exhibiting linkage to another seizure in the same diagram. The integration of such observations is discussed in the examples of the next section.

The “grape” form is clearly not at all a hierarchical representation of cases, seizures and classes. In fact it is always possible to reverse the schema, starting at the upper line with a subgroup present in the actual representation at a lower level, for example the subgroup “Oval”. This means that it is only one way to put some order in the wholeness of the link network choosing independently the starting point (the upper line). Finally it is like choosing the origin of the reference system (principle of Galileo).

The analysis of link networks proved to be efficient when reduced to one or two particular subgroups or classes of seizures. The simultaneous analysis of more entities led to a very complex representation where everything seemed to be connected with everything else. The strategy in adopting this method of analysis for one subgroup and then adopting the same method starting with the other subgroup led to a rather clear representation for an interpretation of the links providing additional intelligence.
IV.3.6.5. Conclusions

At this time it must be pointed out that the collected data and the classification of the seizures are very useful tools for obtaining additional information about the cases. This is very objective information. It is quite clear, too, that the temporal, geographical, and link network analysis of these data can only give restricted additional intelligence information. In fact, it is not possible to expect much more tactical intelligence with the analysis of the restricted, case-related data.

Intelligence as an output of these data has a value only when integrated into the full inquiry. This means, of course, that results must be compared and combined with other intelligence outputs, as for example those coming from the analysis of phone calls and so on.

Forensic intelligence as described above gives an input to the criminal intelligence process, but vice versa, more input from the criminal intelligence to the forensic intelligence could help creating new, interesting knowledge about the entire system.

IV.3.7. Intelligence communication

A rather important point of the intelligence process is the dissemination of results of the analysis. It is difficult to indicate a standardised way of communicating these results, as the communication pathway strongly depends on the “client” receiving it. Intelligence may be transmitted orally (phone calls), in a written report (fax, e-mail, short report, etc.) or as a presentation (meeting, video, etc.).

One common issue in all these communication pathways is the time factor. Almost always, intelligence is needed in real time. It has to be quick, short, and clear. Therefore, it is important to minimise output regulations by the organisational structure. Communication pathways are developing extremely rapidly, and the future will certainly bring new possibilities for intelligence dissemination.

IV.4. PHASE IV: TEST AND VALIDATION

Examples have been chosen to illustrate different ways of gathering intelligence from ecstasy seizures and their classification into subgroups and classes. In analogy to the practice of naming police operations, all examples are covered by a fantasy name. Often these names give an indication as to the most striking characteristic of these subgroups or classes.

All cases are introduced by illustrating the main feature of the example, followed by a step-by-step explanation of the analytical functions, and concluding with a concise summary of the information produced and to be used in subsequent inquiries. All seizures included in the classification are referred to, only with their internal number.

IV.4.1. The “Jumeaux” subgroup

Illustrating All seizures bearing the imprint of twins (in French “Jumeaux”) were found to have common physical and chemical characteristics. The seizures were
combined into the subgroup “Jumeaux” and classified as a similar kind of seizures. Evidence strongly suggests that the tablets come from the same underground laboratory (press and synthesis).

In 15 different seizures, the same imprint showing a schematic figure of twins (from the Zodiac sign of Gemini, but somewhat different from the Solingen Henckels “Zwillingswerk” twins) was found on a total of 524 tablets seized. Of these tablets, 41 were sent to the laboratory for analysis. The following table shows how the 15 seizures were recorded in the database.

<table>
<thead>
<tr>
<th>Internal number of seizure</th>
<th>Imprint description</th>
<th>Tablet shape</th>
<th>Breakline</th>
<th>Colour</th>
<th>Weight</th>
<th>Diameter</th>
<th>Thickness</th>
<th>Illicit substance</th>
<th>Purity</th>
<th>Diluants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light gray</td>
<td>299.2</td>
<td>9.00</td>
<td>4.42</td>
<td>MDMA</td>
<td>28.11</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light gray</td>
<td>281.5</td>
<td>9.00</td>
<td>4.28</td>
<td>MDMA</td>
<td>32.6</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light gray</td>
<td>282.8</td>
<td>9.02</td>
<td>4.28</td>
<td>Not anal.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Beige</td>
<td>293.6</td>
<td>9.00</td>
<td>4.35</td>
<td>MDMA</td>
<td>34.5</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light gray</td>
<td>305.6</td>
<td>9.00</td>
<td>4.39</td>
<td>MDMA</td>
<td>39.95</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Beige</td>
<td>301.5</td>
<td>9.00</td>
<td>4.45</td>
<td>MDMA</td>
<td>42.1</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light beige</td>
<td>292.8</td>
<td>9.00</td>
<td>4.34</td>
<td>MDMA</td>
<td>23.2</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light beige</td>
<td>308.8</td>
<td>9.00</td>
<td>4.41</td>
<td>MDMA</td>
<td>32.9</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light gray</td>
<td>315.9</td>
<td>9.02</td>
<td>4.78</td>
<td>MDMA</td>
<td>37.5</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light beige</td>
<td>314.9</td>
<td>9.00</td>
<td>4.74</td>
<td>MDMA</td>
<td>32.95</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light beige</td>
<td>295.2</td>
<td>9.00</td>
<td>4.67</td>
<td>MDMA</td>
<td>43.45</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light beige</td>
<td>304.0</td>
<td>9.00</td>
<td>4.90</td>
<td>MDMA</td>
<td>37.48</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Light beige</td>
<td>309.6</td>
<td>9.04</td>
<td>4.76</td>
<td>MDMA</td>
<td>26.9</td>
<td>Sorbitol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Beige</td>
<td>286.1</td>
<td>9.02</td>
<td>4.63</td>
<td>Not anal.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA</td>
<td>Yes</td>
<td>Beige</td>
<td>306.4</td>
<td>9.03</td>
<td>4.68</td>
<td>Not anal.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Average                   | 305.8               | 9.02   | 4.68     |
| Number of tablets         | 41                  | 32     | 41       |
| RSD                       | 3.46                | 0.21   | 4.22     |
| RQ                        | 3.36                | 0.25   | 2.35     |

Table IV.4.1.1.: Characteristics of all single seizures of the subgroup “Jumeaux”.
In the codification, all seizures are found to be described with the same tablet shape and the same imprint; all tablets contain a breakline. Only in the colour column, differences were recorded, but always within the relatively narrow range of the colours grey and beige. The variations in the physical data remained at a low level. For the weight of the tablets, a very narrow variation was seen over a period of two years. The chemical composition (MDMA and sorbitol) of the tablets analysed was always the same. The diluent, sorbitol, is not encountered frequently in ecstasy tablets, and therefore constitutes a further indication for a common underground production laboratory. The relative MDMA content varied rather widely between 23.2 and 43.45 %. All seizures were of a similar kind. On this basis, the subgroup “Jumeaux” could be set up with the following general descriptors:

<table>
<thead>
<tr>
<th>Tablet shape</th>
<th>RAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imprint description</td>
<td>Twins (Code 166)</td>
</tr>
<tr>
<td>Breakline</td>
<td>Yes</td>
</tr>
<tr>
<td>Colour</td>
<td>Beige</td>
</tr>
<tr>
<td>Weight</td>
<td>282 – 330 mg</td>
</tr>
<tr>
<td>Diameter</td>
<td>9.02 mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>4.28 – 5.08 mm</td>
</tr>
<tr>
<td>Illicit substance</td>
<td>MDMA</td>
</tr>
<tr>
<td>Diluent</td>
<td>Sorbitol</td>
</tr>
</tbody>
</table>

Table IV.4.1.2.: General descriptors of the “Jumeaux” subgroup.

From the temporal analysis, it was seen that the first seizure occurred in August 1996, the last one in May 1998. Within these 22 months, three different periods (I, II and III) could be distinguished, as shown below: Period I, of five months, followed by six months without any appearance, period II, of two months, again followed by four months without any seizures, finally period III, of five months.
From a geographical point of view, most of the seizures occurred in Zurich, but two seizures were realised south of the Alps in the region of Locarno (canton of Ticino).

Apart from a small variation in the thicknesses, the physical features of the tablets did not reveal any substantial differences between the three periods. In period I, the average thickness was 4.37 mm (RSD 1.45 %), while in periods II and III the thicknesses were 4.77 mm (RSD 0.95 %) and 4.75 mm (RSD 3.14 %), respectively.

In the following graph the correlation of the thickness versus weight is shown for all tablets of period III.

![Graph](image-url)

**Figure IV.4.1.2.: “Jumeaux”, Period III: correlation thickness versus weight for every single tablet analysed.**

This graph shows that outliers with respect to thickness as well as to weight can always be present. However, most of the tablets are grouped together, suggesting that they belong to the same batch of production.

A link network analysis did not reveal any particular relation to other subgroups or classes of seizures.

All these observations strongly support the common origin of the tablets seized, and suggest that at least three different batches were distributed mainly in Zurich. For the two cases seized in the canton of Ticino, a link to Zurich seems very likely. A peculiarity is the low number of seizures made during the second period. Further intelligence about these two cases could be helpful here.
“Jumeaux”
Summary

- Tablets of similar kind, assumed to be produced by the same underground laboratory.
- At least three batches during three distinct periods between August 1996 and May 1998.
- Mainly distributed in Zurich, with some Ticino connection.

Table IV.4.1.3: Summary of “Jumeaux” subgroup.

These recognitions, combined with information and data coming from the inquiry, represent a basis to make important new hypothesis and speculations for further investigations and police operations. This kind of analysis is outside the scope of the present research.

IV.4.2. The “Dromadaire” subgroup

Illustrating In all seizures, the tablets (with the imprint of a dromedary, the trademark sign of Camel cigarettes) were found to have similar physical and chemical characteristics. The seizures were combined into the subgroup “Dromadaire”, and classified as a similar kind of seizures. Evidence strongly suggests that the tablets come from the same underground laboratory. Further temporal and geographical analysis elucidated a relation to another subgroup, “MitsubishiGE”.

All tablets of the nine seizures were found to have the same imprint bearing the Camel trademark sign and exhibiting a yellow colour. These seizures represented nearly 3800 tablets of this kind. The tablets were classified in the same way as described in the previous example, as the subgroup “Dromadaire” having the following general parameters.

“Dromadaire”

Table IV.4.2.1: General descriptors of the “Dromadaire” subgroup.
In two seizures, red traces were observed on the tablets and recorded. Subsequent closer visual observation showed that the tablets of all seizures had red traces on their surface. This observation was further support that all belong to the same subgroup of seizures.

The correlation of thickness versus weight shown in the next figure suggested a separation into two slightly distinct groups: Subgroup I, with an average thickness of 3.94 mm (RSD 1.24), and subgroup II, with an average thickness of 3.69 mm (RSD 0.86). All samples of a given seizure were found to belong, either to I or to II. No seizure was mixed, suggesting the existence of at least two different batches, I and II.

!["Dromadaire". Correlation thickness versus weight for every single tablet analysed](image)

**Figure IV.4.2.1.** “Dromadaire”. Correlation thickness versus weight for every single tablet analysed.

Among the nine seizures, one case (Police number 00/174457) comprising the two seizures 980A and 979C was of particular importance, as in it a total of 3934 tablets bearing three different imprints was seized: the dromedary, a heart in relief on both sides, and tablets without imprint. No seizures are on record which cover tablets similar to the two additional ecstasy types. This is quite unusual, and supports the hypothesis that this case is somehow related to specific import. The inquiry should be concentrated on a closer analysis of this case.

The following representation shows all seizures from Geneva (black) and Zurich (white) on a time axis. The two arrows indicate seizures belonging to batch I.
The temporal analysis showed that the first seizure occurred in Zurich in February 2000, the last one again in Zurich in June 2000. The subgroup “Dromadaire” only appeared over a period of five months. A so-called batch I was seized exclusively in Geneva between March and April, while seizures of a so-called batch II occurred primarily in Zurich, but once also in Geneva. Seizures of a larger number of tablets at the end of the serial representation are always of higher interest, since sometimes they represent the final point of the presence of such a subgroup. Particular attention on these cases may give additional information on distribution habits.

The link network analysis of the “Dromadaire” subgroup relative to other subgroups and classes of seizures revealed some additional features. In the link representation reproduced below, all seizures belonging to the “Dromadaire” subgroup are enclosed in a red box. Related cases with additional interesting seizures were placed on the top of the boxes. No particular subgroup or class of seizure was found to be linked with these other seizures. However, the case including the first seizure made in Zurich (case number 24/00) also included a seizure of tablets belonging to the “MitsubishiGE” subgroup. Exactly as in the “Dromadaire”subgroup, this subgroup has the peculiarity that seizures were made within the same time lapse in Zurich and Geneva. Four additional cases are enclosed in blue boxes.
The general description parameters of the “MitsubishiGE” subgroup are summarised in the table below.

<table>
<thead>
<tr>
<th>“Mitsubishi GE”</th>
<th>Tablet shape</th>
<th>Imprint description</th>
<th>Breakline</th>
<th>Colour</th>
<th>Weight</th>
<th>Diameter</th>
<th>Thickness</th>
<th>Illicit substance</th>
<th>Diluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>861, 873A, 946, 1015A</td>
<td>RCC</td>
<td>Mitsubishi (code 235)</td>
<td>No</td>
<td>Beige/White</td>
<td>321 – 363 mg</td>
<td>9.11 mm</td>
<td>4.4 – 4.74 mm</td>
<td>MDMA (31 %)</td>
<td>Lactose</td>
</tr>
</tbody>
</table>

Table IV.4.2.2.: General descriptors of the “MitsubishiGE” subgroup.

A joint analysis of the time sequence of appearance of the two subgroups, “Dromadaire” and “MitsubishiGE”, is shown in the next graph. All seizures of the “Dromadaire” subgroup are plotted on the upper two lines, the seizures of the “MitsubishiGE” subgroup are plotted on the lower line.
Figure IV.4.2.4: Temporal representation of the two subgroups “Dromadaire” and MitsubishiGE”.

It is seen that the two subgroups appeared in sequence: first the “MitsubishiGE” from September 1999 to January 2000, then the “Dromadaire” from January to June 2000.

In conclusion, both a geographical and a temporal relation between the subgroups of “MitsubishiGE” and “Dromadaire” has been uncovered. For further inquiry, the following three cases should be of interest: GE 00/174457, where nearly 3800 tablets have been seized, which probably stopped dissemination of the so-called batch I of “Dromadaire” tablets; ZH 24/00, which included seizures of “Dromedaire” (1015B) and “MitsubishiGE” (1015A) tablets and could be useful for finding new intelligence about the Zurich-Geneva link; and ZH 690/00 involving the seizure of 283 tablets in June 2000, which seems to have stopped the spread of tablets of this kind.

<table>
<thead>
<tr>
<th>“Dromadaire”</th>
<th>“MitsubishiGE”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary</strong></td>
<td></td>
</tr>
<tr>
<td>- Tablets of similar kind, with the imprint of a dromedary, assumed to be produced by the same underground laboratory.</td>
<td></td>
</tr>
<tr>
<td>- At least two batches have appeared, one in Geneva that was stopped by the seizure of nearly 3800 tablets, the other with seizures spread out over Zurich and Geneva.</td>
<td></td>
</tr>
<tr>
<td>- Geographical and temporal ties with the subgroup “MitsubishiGE”.</td>
<td></td>
</tr>
<tr>
<td>- Selection of three cases (GE 00/174457, ZH 24/00 and ZH 690/00) for further investigation elucidating dealer activity and connections between Geneva and Zurich.</td>
<td></td>
</tr>
</tbody>
</table>

Table: Summary of the subgroups “Dromadaire” and “MitsubishiGE”.

Christian Zingg, IPS Lausanne
IV.4.3. The “RAABleu” subgroup

Illustrating Classification has been performed for tablets without an imprint. Seizures of blue tablets without an imprint having common physical and chemical characteristics were classified and combined into the subgroup “RAABleu”. Further analysis showed ties to three other subgroups (“Oval”, “ThioStar”, and “Love”) and to the class of “wColStrie”.

Tablets of 12 seizures without any imprint were found to have common physical and chemical characteristics. The initial combination of parameters was given by the absence of an imprint, the blue colour, and the diameter. In one case (seized in Zurich 25 July 1998) two groups of tablets (seizures 775A and 775B) slightly different in colour were found together; for this reason this slight difference was disregarded in the classification. The following table gives the parameters of the subgroup “RAABleu”.

<table>
<thead>
<tr>
<th>Tablet shape</th>
<th>Imprint description</th>
<th>Breakline</th>
<th>Colour</th>
<th>Diameter</th>
<th>Illicit substance</th>
<th>Diluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;RAABleu&quot;</td>
<td>RAA</td>
<td>No imprint</td>
<td>No</td>
<td>8.05 mm</td>
<td>MDMA (49 %)</td>
<td>Lactose</td>
</tr>
</tbody>
</table>

Table IV.4.3.1.: General descriptors of the “RAABleu” subgroup.

A total of 29 tablets was transmitted to the laboratory from all seizures of this subgroup. The statistical evaluation of thickness and weight revealed rather large variations. The weights of the tablets went from a minimum of 156 mg to a maximum of 242 mg per tablet (average of 210 mg with RSD of 12 % and RQ of 19 %). The thicknesses went from a minimum of 3.3 mm to a maximum of 4.1 mm per tablet (average of 3.87 mm with RSD of 7.6 % and RQ of 13.9 %).
A plot correlating the weights and thicknesses of all tablets revealed three tablet types (I, II and III). Contrary to the observations made in a later example, it was not possible to find single seizures including exclusively just one of these three types of tablets.

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>182 mg (RSD 6.7 %)</td>
<td>232 mg (RSD 2.6 %)</td>
<td>190 mg (RSD 3.1 %)</td>
</tr>
<tr>
<td>Thickness</td>
<td>3.46 mm (RSD 2.9 %)</td>
<td>4.08 mm (RSD 2 %)</td>
<td>4 mm (RSD 1.2 %)</td>
</tr>
</tbody>
</table>

The following representation shows that one seizure included tablets of types I and II, two seizures included tablets of types II and III. For this reason it was necessary to classify all seizures within the same subgroup “RAABleu”, and attach less importance to weight and thickness of the tablets.
A representation on the time scale shows that seizures in this subgroup occurred in the illegal market, mainly over a period of five months between June and October 1998. One latecomer (seizure 1045C) appeared about two years later, in March 2000. A particularly high number of seizures occurred in July 1998.

The above representation includes the geographical component, inasmuch as Zurich is shown in blue, Neuchâtel in black, and Lugano (Canton of Ticino) in red. The first seizure occurred in Neuchâtel, but the largest number of seizures occurred in Zurich. The seizure in Lugano was the last one during the main period, supporting the hypothesis that the supplier originated from the Zurich region.

The two largest seizures (with 1035 and 12304 seized tablets, respectively) are shown with thicker frames.

The link network representation provides some more information. All seizures classified as “RAABleu” are within the upper blue box; they are arranged from left to right in a chronological order. Related cases are listed one line down; cases covering the two large seizures described before are represented by a larger icon. Other classified seizures of these cases are shown at the bottom; they are arranged in a number of red boxes, while all other nonclassified seizures are listed as a complement at the very top of the representation.
Figure IV.4.3.3.: Example of the linking network.

This figure shows that in five cases out of 11, the two kinds of tablets classified as “RAABlue” and “Oval” were found together; this represents nearly 50% of the cases recorded. This observation strongly supports a tie between the two subgroups, either on a dealer level or on a manufacturing level. The main characteristics of the “Oval” subgroup are given below.

Table IV.4.3.3.: General descriptors of the “Oval” subgroup.

Seizures belonging to other subgroups (“ThioStar”, “Love”, and “wColStrie”) are placed into the respective red boxes at the bottom of the figure. Interesting new seizures related to the four additional subgroups are shown in the black boxes in the lower right corner. A further close evaluation of inquiry information on these 12 cases in relation to the “RAABlue” cases could lead to additional intelligence. Particular emphasis should be placed on the four cases of the “Oval” subgroup.
• Blue tablets without an imprint were found in 11 cases and were classified as “RAABleu”.

• The link network shows a particularly tight relation with the “Oval” subgroup and some ties to the subgroups of “Love” and “ThioStar”, as well as to the class of “wColStrie”.

• Further inquiry should be of interest in the two large seizures (cases 5193/98 and 802/98).

• A case of particular interest is the case 540/00, which had appeared two years later, since it was in addition related to the “Oval” subgroup.

Table IV.4.3.4: Summary of the subgroups “RAABleu” and “Oval”.

### IV.4.4. The “Ferrari” class

Illustrating From tablet seizures with imprints showing the horse of the trademark sign of Ferrari, a “Ferrari” class has been constituted. Temporal and geographical analyses revealed ties with seizures of tablets having a smaller diameter.

Within the entire database, different seizures covering tablets having a horse as imprint were found. The following different types of copies of the Ferrari trademark sign were distinguished:

Table IV.4.4.1: Photographs of different horse imprints.

In 12 seizures these imprints were recorded. Marks were identified on the imprint with shield, as mentioned previously, and closer examination showed that there were three types of these marks (A, B and C) among the various seizures. Most of the seizures included more than one type of imprint. All seizures could be defined as belonging to the same type of tablets.
A closer comparison showed that there were some further visual as well as chemical differences within the seizures. Particular importance was attached to the observation that the tablets of some seizures had several red points, those of other seizures had several beige points, while the tablets of other seizures were completely white, as shown in the next table.

<table>
<thead>
<tr>
<th>Internal number</th>
<th>Total number of tablets seized</th>
<th>Observation</th>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
<th>Number of samples analysed</th>
</tr>
</thead>
<tbody>
<tr>
<td>915B</td>
<td>15</td>
<td>With beige points</td>
<td>X</td>
<td>X</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>916B</td>
<td>28</td>
<td>With beige points</td>
<td>X</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>934A</td>
<td>13</td>
<td>With red points</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>4</td>
</tr>
<tr>
<td>936A</td>
<td>53.5</td>
<td>With red points</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>4</td>
</tr>
<tr>
<td>938</td>
<td>14</td>
<td>With red points</td>
<td>X</td>
<td>X</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>942</td>
<td>29.25</td>
<td>With red points</td>
<td>X</td>
<td>X</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>970A</td>
<td>79.5</td>
<td>With red points</td>
<td>X</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>970B</td>
<td>79.5</td>
<td>With red points</td>
<td>X</td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>970C</td>
<td>79.5</td>
<td>With red points</td>
<td></td>
<td>X</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>997</td>
<td>54</td>
<td>White</td>
<td>X</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1004B</td>
<td>40</td>
<td>White</td>
<td>X</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1019</td>
<td>18.5</td>
<td>White</td>
<td>X</td>
<td>X</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

*Table IV.4.4.3.: Differences of the different seizures within the “Ferrari” class.*
On the basis of these observations, these seizures could be divided into three distinct subgroups: “Ferrari-Rouge”, “Ferrari-Beige” and “Ferrari-Blanc”, all belonging to the “Ferrari” class. Their main characteristics are given in the following table.

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Tablet shape</th>
<th>Imprint description</th>
<th>Breakline</th>
<th>Colour</th>
<th>Diameter</th>
<th>Thickness</th>
<th>Weight</th>
<th>Illicit substance</th>
<th>Diluents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Ferrari-Beige”</strong></td>
<td></td>
<td></td>
<td>RCC</td>
<td>Horse</td>
<td>No</td>
<td>Dirty white</td>
<td>9.1 mm</td>
<td>3.84 – 4 mm</td>
<td>Lactose, phosphate</td>
</tr>
<tr>
<td>916B, 915B</td>
<td>[Image]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.8 – 4 mm</td>
<td>285 – 309 mg</td>
<td></td>
</tr>
<tr>
<td><strong>“Ferrari-Rouge”</strong></td>
<td></td>
<td></td>
<td>RCC</td>
<td>Horse</td>
<td>No</td>
<td>Dirty white</td>
<td>9.1 mm</td>
<td>3.4 – 3.92 mm</td>
<td>Lactose</td>
</tr>
<tr>
<td>936A, 934A, 938, 942, 97ABC</td>
<td>[Image]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.4 – 3.92 mm</td>
<td>271 – 315 mg</td>
<td></td>
</tr>
<tr>
<td><strong>“Ferrari-Blanc”</strong></td>
<td></td>
<td></td>
<td>RCC</td>
<td>Horse</td>
<td>No</td>
<td>White</td>
<td>9.1 mm</td>
<td>3.86 – 4.14 mm</td>
<td>Lactose</td>
</tr>
</tbody>
</table>

Table IV.4.4.4: General descriptors of the subgroups “Ferrari-Beige”, “Ferrari-Rouge” and “Ferrari-Blanc”.

The temporal analysis of the “Ferrari” class is shown in the next figure.
This figure shows that the three subgroups appeared sequentially in Zurich: first “Ferrari-Beige” (September 1999), then “Ferrari-Rouge” (November/December 1999), finally “Ferrari-Blanc” (December 1999 to February 2000). The only exception to this sequence was the single case from the canton of Ticino (seizure 970) recorded in February 2000. The “Ferrari” class as a whole was present particularly in Zurich, for the six-month period between September 1999 and February 2000. The three subgroups appeared over much shorter periods of time.

In the following link network figure, all seizures belonging to the “Ferrari” class are shown in the red box at the top.
Both cases belonging to “Ferrari-Beige” also included the seizure of tablets belonging to the subgroup “Num8”. In other seizures any particular, common subgroup could not be distinguished. However, in this example another feature seems to be of importance. In fact, a closer look at all additional seizures revealed a high frequency of small tablets. As shown by photographs in the link network figure, three types of tablets having a diameter of about 7 mm (the subgroups “Num8” and “Japo2” [character meaning “a well”] as well as the seizure showing the letters “XTC”) all appeared in connection with seizures belonging to the “Ferrari” class. A diameter of 7 mm is not frequently found in ecstasy tablets, therefore this large number of tablets cannot be assumed to be accidental.

Two hypotheses can be put forward concerning the origin of this feature. Either the drug dealer behind all these cases has two different suppliers, one for the Ferrari tablets and one for the small 7 mm tablets. Or, a laboratory is producing both types of tablets, probably with two tabletting machines.

Inquiry priority should here be given to the cases including seizures with both types of tablets. Also, the authorities of the canton of Ticino have support for the assumption that the supplier is from Zurich.
• Three subgroups appeared sequentially in Zurich over a period of six months (Ferrari-Beige, Rouge, and Blanc).

• The high frequency of seizures including tablets with a diameter of 7 mm which occurred together with tablets of the “Ferrari” class suggests that the relation between these cases be investigated.

• For the authorities in the canton of Ticino, it is highly probable that the “Ferrari” tablets seized came from the region of Zurich.

Table IV.4.4.5: Summary of the “Ferrari” class.

IV.4.5. The “DiamantVS” class

Illustrating This example shows that it is possible to regroup different subgroups into more complex classes. The “DiamantVS” story started with a request made by the cantonal police of the canton of Valais, who wanted to know whether tablets like those of their seizure 1031 had already been found elsewhere.

On 7 July 2000, the police of the Valais made a seizure of 192.5 tablets in Sierre. Because of the rather large number of tablets and because of some hints received during inquiry that there might be a link to the Netherlands, a request for more information was made to our laboratory. The tablets showed the imprint of a diamond and had a rather rare chemical composition, viz., they contained the illicit substance MDA. Also, all tablets were coloured.

Triggered by this request, a general classification of tablets having the same kind of physical characteristics and containing MDA was introduced and in a first phase led to a subdivision into five subgroups combined into the “DiamantVS” class. As shown in the next table, all seizures represented the same kind of tablet shapes and, except for one, the same imprint. The subdivision into subgroups was mainly made on the basis of slight differences in chemical composition of the diamond tablets. The initial seizure (1031) mentioned was entered into the “Diamant-C” subgroup. An identification and quantification of the dye as a second-step priority, as proposed by Goldmann [Goldmann, 2000], could serve to confirm the subgroups created, or give additional information about still further subgroups.

| “Diamant-A” | Tablet shape | RBA | Diamond  
| 922 | Imprint description | No | No  
| | Breakline | Rose/violet | Rose/violet  
| | Colour | 8.1 – 8.5 mm | 8.1 – 8.5 mm  
| | Diameter | 3.94 – 4.6 mm | 3.94 – 4.6 mm  
| | Thickness | 220 – 255 mg | 220 – 255 mg  
| | Weight | MDA (28 %) | Lactose  
| | Illicit substance | Lactose | Lactose  
<p>| | Other substances | | |</p>
<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Tablet shape</th>
<th>Imprint description</th>
<th>Breakline</th>
<th>Colour</th>
<th>Diameter</th>
<th>Thickness</th>
<th>Weight</th>
<th>Illicit substance</th>
<th>Other substances</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Diamant-B”</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RBA</td>
<td>Diamond</td>
</tr>
<tr>
<td>952, 1011, 1179A, 1198</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Rose/violet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.06 – 8.14 mm</td>
<td>3.56 – 3.6 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>202 – 222 mg</td>
<td>MDA (27 %)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ephedrine, lactose</td>
<td></td>
</tr>
<tr>
<td><strong>“Diamant-C”</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RBA</td>
<td>Diamond</td>
</tr>
<tr>
<td>1031, 1091, 1118</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Rose/violet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.14 – 8.2 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.26 – 3.4 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>203 – 218 mg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MDA (26 %)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Caffeine (traces), ephedrine (traces), lactose</td>
<td></td>
</tr>
<tr>
<td><strong>“Diamant-D”</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RBA</td>
<td>Diamond</td>
</tr>
<tr>
<td>1038DE, 1039BCD, 1100, 1112F, 1121, 1140B, 1145, 1148, 1152A, 1154, 1200, 1203A, 1205A, 1209, 1286, 1288, 1291A, 1320, 1397C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Rose/violet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.14 – 8.3 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.39 – 3.94 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>214 – 255 mg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MDA (23 %)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Caffeine (traces), lactose, mannitol (traces)</td>
<td></td>
</tr>
<tr>
<td><strong>“Diamant-Ecl”</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RBA</td>
<td>Two lightning arrows</td>
</tr>
<tr>
<td>1204A, 1199A, 1218A, 1322B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Rose/violet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.12 – 8.26 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.02 – 4.28 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>266 – 282 mg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MDA (23 %)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Caffeine (traces), lactose, mannitol (traces)</td>
<td></td>
</tr>
</tbody>
</table>

Table IV.4.5.1.: General descriptors of subgroups belonging to the “DiamantVS” class.
About one month later, tablets from another seizure were sent to our laboratory by the same police corps with the remark that one “similar” case (seizure 1198) had been found previously, but had been regarded as unimportant (total seizure of 1.5 tablets). The analysis and classification of these tablets showed that they were linked to the Diamant-B subgroup. Therefore, it could be communicated that this earlier case was related to three other cases of seizures in Zurich that had occurred at least six months before. Further inquiries by the police confirmed that this had already occurred in January.

Further police investigations led to the seizure at the border in Basel of 305 yellow tablets coming from the Netherlands. The analysis of these tablets revealed a close relationship to the “DiamantVS” class of tablets. The properties of the two subgroups “Diamant-Jau1” and “Diamant-JauR” are shown in the next table. Apart from the seizure in Basel, no other case was found which included tablets belonging to more than one of these subgroups.

<table>
<thead>
<tr>
<th>“Diamant-Jau1”</th>
<th>“Diamant-JauR”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tablet shape</strong></td>
<td>RBA</td>
</tr>
<tr>
<td><strong>Imprint description</strong></td>
<td>Diamond</td>
</tr>
<tr>
<td><strong>Breakline</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>Yellow</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>8.0 mm</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>2.14 – 2.2 mm</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>115 – 119 mg</td>
</tr>
<tr>
<td><strong>Illicit substance</strong></td>
<td>MDA (52 %)</td>
</tr>
<tr>
<td><strong>Diluents</strong></td>
<td>None</td>
</tr>
</tbody>
</table>

*Table IV.4.5.2.: General descriptors of additional subgroups belonging to the “DiamantVS” class.*

The temporal representation of all seizures belonging to the “DiamantVS” class showed that there is a chronological order of appearance among the different subgroups: first “Diamant-A” (September 1999), then Diamant-B (October 1999 to April 2000), “Diamant-C” (June/July 2000), then the main group of seizures “Diamant-D” (between June and October 2000) and two latecomers in January and August 2001, at the same time a subgroup “Diamant-Ecl” with a latecomer in January 2001.
It is interesting to note that apart from the latecomers, after the seizure of the new yellow tablets at the border in Basel in December 2000, no further seizure of subgroups related to this class have occurred. Since the first appearance in the seizure in Basel, a time of 14 months had passed, and at least five different batches have appeared on the Swiss market.

In the following table, different places of seizure are shown in different colours. Tablets of this class have been seized in Zurich (black), Neuchâtel (blue), the canton of Valais (red), the canton of Ticino (purple), and Lausanne (green). Further intelligence gathering over the European Network of Forensic Institutes showed that tablets of this kind had been found in the Netherlands and in Italy.
Number of tablets per seizure, grouped by police corps

Figure IV.4.5.2.: Number of tablets per seizure, grouped by police corps.

In terms of the number of tablets, it is seen from this graph that only four major cases were seized: one in Zurich, one in Neuchâtel, one in the Valais and one in Basel (the one already discussed). It is also seen that tablets of this type have appeared at least in five different regions (Zurich, Neuchâtel, Valais, Ticino and Lausanne).

The next figure provides a general view of the linking network. Red boxes represent the subgroups. In this figure, only classification links to other relevant subgroup are shown.

Figure IV.4.5.3.: The link network of the “DiamantVS” class.
The link network shows the seven subgroups of the “DiamantVS” class within the red boxes. From this figure it can be seen that no cases were found which would constitute a tie between seizures of the five subgroups of “Diamant-A”, “Diamant-B”, “Diamant-C”, “DiamantJau1” and “Diamant-JauR, except of course for the fact that the last two subgroups were seized together. Between the subgroups “Diamant-D” and “DiamantEcl”, some relations were uncovered. A closer look at this part is shown in the following figure.

Figure IV.4.5.4.: Detail of the link network representation.

The blue boxes regroup other classes or subgroups related to the subgroups of “DiamantEcl” and “Diamant-D”. In two different cases, tablets belonged to the “Diamant-D” and “DéfautStrie” subgroup. In three other cases, tablets related to the “Thailande” class were seized in addition to “Diamant-D” tablets.

An indirect relation was found in three cases. This interconnection concerns the subgroup of “JamesBond” and the classes of “Xhi” and “Snoopy”. These interconnections suggest that it will be of interest to take a closer look at these linked cases.

A time diagram of the additional seizures shows the following situation.
According to this temporal analysis, it is seen that the class of “Snoopy” disappeared at the same time as the “DiamantVS” class, except for the latecomers mentioned. On the other hand, the other two classes, “JamesBond” and “Xhi”, appear not to have stopped. Of particular interest should be the “Xhi” class, which actually started after the end of “DiamantVS”.

**“DiamantVS”**

**Summary**

- The seizure in Basel constituted the actual end of the “DiamantVS” class. The role of this inquiry goes far beyond the fact of seizing 305 tablets.
- The subgroup “Snoopy” appeared and disappeared within the same lapse of time as the “DiamantVS” class.
- This class of tablets revealed relations between different regions, although with a high concentration in Zurich.
- The four major cases found in different regions should be analysed on the inquiry level to gather further intelligence.
As explained before the “DiamantVS” class was subject of a police operation in the canton of Valais. This class example shows the possibility to evaluate for example the efficiency of a police operation. The fact that no tablets of the yellow type, seized at the border in Basel, and the fact that after this seizure only a few little cases belonging to this class of ecstasy tablets were seized makes stronger the hypothesis that the arrest of Basel touched an important part of the investigation; perhaps the head. A closer pure investigative analysis of this person, arrested because of knowledge gathered by the police in Valais, according to his role in Zurich would have given a clear image of this regional traffic organisation and other secondary players.

IV.5. FINAL REMARKS

Seized ecstasy tablets may be described in many different ways qualitatively and quantitatively, but the wide range of characteristics have never been thoroughly and systematically defined with regards to their usefulness in providing information for investigative activities. The prime objective of this thesis was to establish such defined parameters, useful in a forensic drug intelligence perspective.

Clearly there may be conflicting views concerning the selection and the depth of parameters selected, but operational usefulness has led to choices, which present measurable usefulness. All visual, physical, and chemical parameters retained in this perspective have been described in detail in the chapter “Materials and Methods”, with specific emphasis on selectivity, sensitivity, reproducibility, cost, simplicity and rapidity. For some of these characteristics, a number of different methods of analysis or description are available, for instance for the colour of the tablets. These have been carefully studied and compared, in order to finally select those that appeared the most suitable for this work. Finding an optimal method of analysis nearly always led to some form of compromise to reach a equilibrium between the different properties measured. It even revealed an antagonism between selectivity and rapidity of any given analytical method.

Selective and simple methods applicable in different laboratories and services rapidly demonstrated that they could be exchanged and applied with a high degree of accuracy and precision across laboratories, thus facilitating exchange. On this basis it has been possible to pursue and apply this work outside the research laboratory, in an operational environment. Thus all data from the WD (Zürich City Police Laboratory) in Zurich have been codified accordingly and systematic exchange has shown a demonstrable improvement in the quality of the information shared.

One avenue, by analogy with the chemical methods already applied to the forensic analysis of heroin and cocaine, was evaluated to see whether elemental and chemical profiling of ecstasy tablets could be helpful in attaining the main goal of this work.

From a theoretical point of view it was expected that the elemental profile of ecstasy tablets should give information about the synthetic pathways used when producing the powder and further contaminated from the step of mechanical compression and would therefore represent a trustworthy elemental profile of the sample tablets found in illicit traffic. In the routine analysis of heroin and cocaine, a restricted number of common elements have been analysed, while in the case of ecstasy tablets, a nearly complete profiling of elemental composition was performed with IPC-MS [Comment, 1999]. It was seen from the results that this rather complex chemical analysis did show potential in demonstrating common source by
comparison, but could not be used a “classifier“ for the kind of classification of the seizures aimed at in this work. It showed that the inorganic composition of tablets represented additional information that could be used when comparing production batches, when looking at a group of suspect product from perceived linked cases.

Similarly, the analysis of trace substances in illegal products by gas chromatography, which yields a trace profile, will provide useful links between samples coming from any given production batch. In the case of ecstasy tablets, the trace profiles of organic compounds are particular, because they arise from the initial production of the illicit powder and their presence and proportion will result from laboratory synthesis conditions. This is again a useful analysis for comparison of samples rather than classification.

These are the main reasons why it was deliberately decided not to include these trace profiles in the evaluation of data for forensic intelligence purposes. In fact, this is a problem much more relevant to the judicial context, and it was dealt with in a separate study as a specific issue [Lock, 1997][SMT, 2003].

It was seen from early experiments that analytical methods developed for the profiling of amphetamine powder seizures were not immediately applicable to tablets containing the illicit substance together with additional compounds in a compressed matrix (the tablets). Particularly in the presence of fatty acids, new extraction methods had to be tested. Therefore, trace profiles were regarded as a second-priority method. In fact, it proved to be much more efficient to first identify seizures belonging to a common traffic network, by classifying the products seized in the way described in this work, followed by analyses that allow to apply the comparison to a restricted number of samples in order to find links to common chemical production batches of the illegal substance, rather than analysing routinely and systematically all seizures of ecstasy tablets.

Linked cases through the selected categories, when further analysed did not necessarily show a complete match, when doing a more detailed comparison. This contributes to strengthen the unverified common knowledge based on the views and the information gathered through inquiries concerning seized clandestine laboratories in other countries: it seems likely that, commonly, more than one production batch of the illegal substance is used to supply the needs for the production of one batch of tablets. These different batches of substances may even come from different laboratories using different ways of synthesis. The two steps in the process, which is typical in production of ecstasy tablets, is the source of diversity observed when comparing samples known to have a common source, but with different profiles. This confirms what is known otherwise about the technical conditioning of the powder for the tabletting process. To believe that the powder is homogeneously mixed, and could constitute a unique chemical mixture within a given batch of tablets can therefore be a lure. In fact, the differentiation that is possible within a given batch of tablets may then reveal chemical links to pure synthesis batches. From an intelligence point of view, within given tablet sample seizures this differentiation would not reduce false negatives and would be in contradiction with the declared objective of the project. Instead, it provides an additional subdivision of interest that is not primarily contributing to the classification of seizures belonging to given trafficking networks, but for studies of synthetic pathways or comparison for court purposes.

In the present work the assumptions were made that tablets seized in a given container were representative of a particular traffic level, allowing some interpretation as to production (including the synthesis step and the compression step). Differences within a given seizure (as for example special marks in the “Ferrari” class) can provide the basis for certain hypotheses (for example, the use of a multi-punch machine), but the samples of ecstasy
tablets selected for classification do not constitute adequate sampling populations to infer common source. It may be reasonable indicators for selecting investigation hypothesis.

The reproducibility and frequency of all the characteristics described here, resulting from the analysis of tablets seized from a given clandestine laboratory would help create insider knowledge useful in refining possible inferences in the intelligence process. This would constitute the basis of understanding the levels of samples to determine inferences and make fine interpretation of overall production processes. So far it is only possible to make indirect and incomplete inferences through the exposed limitations discussed earlier. Such samples, coming from the same clandestine laboratory, would also represent the population of choice for an evaluation of chemical trace analysis, particularly in order to arrive at a correct interpretation within a batch of tablets, all coming from the same compression (or tabletting) run, but containing material from different synthesis batches.

Samples of this kind have not been and still are not available in Switzerland, as no press has ever been seized till now. Close collaboration with foreign services (for example the Netherlands) could provide the material needed for further work in this sense.

Results generated by studying samples known to have come from the same clandestine laboratory would be the best basis for an inverse validation of the classes and production batches which have been described in this work while relying on samples seized by some Swiss police services. Although these are limitations, the case example arising from solved investigations in Switzerland give an insight in the value of the features I have described to lead to reasonable inferences with regards to drug traffic and to a certain extent, its organisation has been described (this is shown by the “DiamantVS“ case, see chapter IV.4.5.).

The sample set chosen, represented nearly 50% of the ecstasy tablets seized by police in Switzerland between 1997 and 2000. The classification proved to be the most pragmatic way of working. As documented by the examples chosen, the classification relies on a systematic analysis of mostly qualitative characteristics, and more particularly on the evaluated frequencies. In any other region comparable to the Swiss territory, this approach could be applied in the same way. For the comparison of data coming from a much larger data base, covering for example all seizures in the European Union, this approach may be of more limited utility, although it was not possible to measure this. Detailed studies of such a sample set would be of general strategic interest. Such a data set has not been compiled so far and would need close collaboration between numerous laboratories that are case oriented and do not bother with classification methods for intelligence purposes.

Further integration of additional intelligence gathered from the forensic data in the inquiry process is a possible extension of interest. Thus, the automatic production of pictures (maps) for the geographic and time distribution of classes and apparent batches could serve to improve the utility of these forensic intelligence analyses in daily inquiries. A particular characteristic found for the sample seized should be automatically referenced to its frequency in the database or in a particular time window.

In conclusion, it has been possible in this research to prepare and systematically represent a useful data set for analysing tablets coming from seizures in Switzerland. This set represents a solid base of knowledge of what we have in Switzerland. Mainly because of the sampling strategy, only certain interpretations are possible, but this should be greatly improved, if implementing the avenue described before and may be part of further research projects and/or through general implementation within the country.
V. CONCLUSIONS

V.1. GENERAL ASPECTS

The role of forensic illicit substance analysis was, and is still, that of providing evidence for court proceedings and determining whether or not the seized materials contain controlled drugs. The support of operational and strategic criminal investigations by a knowledge of analytical features of the illicit substances is a more recent development. It belongs to the new concept of forensic intelligence. Ecstasy tablets appeared to be a particularly favourable subject for examination with a drug intelligence perspective, because of the number of cases, the diversity and existing research links with four cantonal police services.

The principal aim during the first phase of this work was that of choosing visual, physical, and chemical analysis methods according to a few basic principles. Particular importance was given to the time factor, in accordance with the saying that the best information is useless when coming late. Fundamental to this itinerary was the development and continuous improvement of the XTC database.

To enhance the value of the data collected, particular attention was given to the aspect that they be really representative. An impressive number of seizures of ecstasy tablets (1093 seizures during three years) that had occurred in all major parts of the country, selected with due regard to linguistic, social, and national-border aspects, were analysed, recorded, and evaluated in a rather time-consuming operation. This solid base of data allowed a vast population of physical and chemical data to be interpreted, thus giving a reliable perception of the illegal ecstasy market. Speculations concerning samples that appeared during this time have been avoided as they are outside the scope of this research.

The classification and the description of seizure links according to their features was the main subject of the second phase of this work. Terms and procedures were carefully defined.

Some representative examples discussed in conclusion serve to procure some familiarity with the standard methodology used to gather information from the XTC database and to derive valuable intelligence. In some cases these results have been validated by police operations. Compared to standard drug analysis procedures, the present kind of information proved to be of a completely different utility. The temporal, the geographical, and the linking-network analysis each serve to reveal important aspects of the illicit ecstasy market.

This study provides examples of intelligence potential in the particular and restricted domain of ecstasy tablets. The concrete or on-line use of this information in inquiries has not been studied so far, but should be an interesting topic of future work. The information exchange between forensic intelligence and criminal intelligence must be developed in subsequent research. An operational project going in this direction was initiated between the WD and the IPSC, and should draw profit from the new possibilities opened up by this approach.

Similar methodologies have been tested by Guéniat and Esseiva in the classification and information gathering concerning other drugs such as heroin and cocaine.
The analysis of drugs of abuse has always had some touch of monotonous routine work. The perspectives of intelligence use described will provide a completely different dimension to this fascinating domain of investigation.

V.2. SPECIFIC FURTHER WORK

The limited scope of a research project usually leads to multiple potential avenues for further studies or for implemented strategies. The major results of a piece of scientific work do not normally close an issue, with the assumption that all possible questions have been answered, but rather open the door for new questions formulated on the basis of new knowledge and insight.

Important perspectives resulting from the present work may be selected as follows:

- The proposed basic method for the collection of data on ecstasy tablets, and the demonstration that the classification way has potential as an efficient approach to intelligence analysis, provide a starting point for the following two main issues:
  - Implementation of the method of analysis
  - Development and gathering of operational results.

- A large potential for development exists with respect to appropriate methods of visualisation, particularly on a geographical basis and on a time basis. The development of maps used interactively to situate linked and non-linked seizures in any particular region could be of great benefit for practical intelligence work.

- Concrete efforts of introducing this kind of intelligence into the inquiry process require detailed analysis and studies.

- An integration of representations of frequency in the intuitive procedure of intelligence analysis as well as in other possible methods of analysis could be highly desirable.

- Efforts in chemical profiling for the purposes of batch comparison should be made with particular emphasis on tablets containing MDMA as the illicit substance, as this is still the most popular kind of substance contained in the illicit, sold tablets.
VI. REFERENCES


VII. ANNEXES

VII.1. ANNEX 1: CLASSIFICATION OF ILLICIT CONTROLLED SUBSTANCES

See next page.
<table>
<thead>
<tr>
<th><strong>NATURAL DRUGS</strong></th>
<th><strong>SYNTHETIC DRUGS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cannabis</strong></td>
<td><strong>Amphetamines and derivatives</strong></td>
</tr>
<tr>
<td>Hashish, resin,</td>
<td>Speed, Ice, Gold Fish…</td>
</tr>
<tr>
<td><em>Marijuana</em>, Hemp,</td>
<td>Ecstasy, XTC, Adam, Eve,…</td>
</tr>
<tr>
<td>Hashish oil, Canapa, Gras, Kif, Pó, Gianja, Chanvre, Bhang,…</td>
<td><strong>LSD</strong></td>
</tr>
<tr>
<td><strong>Opiates</strong></td>
<td><strong>LSD</strong></td>
</tr>
<tr>
<td>Heroin, Black tar, Opium, Chandu, Horse,…</td>
<td>Trip, Acid, LSD 25</td>
</tr>
<tr>
<td><strong>Coca</strong></td>
<td><em>Others</em></td>
</tr>
<tr>
<td>Coca leaves, Coke, Erythroxylon coca, Coca paste, Snow, Crack, Neurocaine,…</td>
<td>Lysergide,</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td><strong>Others</strong></td>
</tr>
<tr>
<td>Catha Edulis (Khat)</td>
<td>- Benzodiazepines</td>
</tr>
<tr>
<td><strong>Amphetamines</strong></td>
<td><strong>Others</strong></td>
</tr>
<tr>
<td>Diacetylmorphine, Diamorphine, Acetomorphine, Morphine, Codeine, Noscapine, Meconine, Papaverine, 6-Monoacetylmorphine, Acetylscodeine,…</td>
<td><strong>Barbiturics</strong></td>
</tr>
<tr>
<td><strong>LSD</strong></td>
<td><strong>PCP</strong></td>
</tr>
<tr>
<td><em>Synthesized</em></td>
<td>MDA, MDMA, MDEA, MBDB,…</td>
</tr>
<tr>
<td>Related substances</td>
<td>N,N-Diethyl-dlysergamide (LSD)</td>
</tr>
<tr>
<td>Δ9-Tetrahydrocannabinol (Δ9-THC)</td>
<td>- Benzodiazepines</td>
</tr>
<tr>
<td>Cannabinol (CBN)</td>
<td>Diazepam</td>
</tr>
<tr>
<td>Cannabidiol (CBD)</td>
<td>- Barbiturics</td>
</tr>
<tr>
<td>Cannabinolic acid,…</td>
<td>Barbital</td>
</tr>
<tr>
<td><strong>Principal active substance</strong></td>
<td><strong>PCP</strong></td>
</tr>
<tr>
<td>Δ9-THC</td>
<td>Psilocybin</td>
</tr>
<tr>
<td><strong>Usual physical appearance</strong></td>
<td>Methaqualone</td>
</tr>
<tr>
<td>Green herbal material</td>
<td>Phencyclidine</td>
</tr>
<tr>
<td>Brown pressed slabs</td>
<td>Methaqualone</td>
</tr>
<tr>
<td>Dark viscous oil</td>
<td>- Methaqualone</td>
</tr>
<tr>
<td>White and brownish powder</td>
<td>Tablet paper</td>
</tr>
<tr>
<td>Pressed blocks</td>
<td>Small tablets (microdotted)</td>
</tr>
<tr>
<td>Coca leaves</td>
<td>Gelatine forms</td>
</tr>
<tr>
<td><strong>Methods of use</strong></td>
<td><strong>Medical Use</strong></td>
</tr>
<tr>
<td>Smoked</td>
<td>Analgesic</td>
</tr>
<tr>
<td>Oral</td>
<td>None</td>
</tr>
<tr>
<td>Injected</td>
<td>Local anaesthetic</td>
</tr>
<tr>
<td>Smoked</td>
<td>Narcoleptic, Wight control</td>
</tr>
<tr>
<td>Sniffed</td>
<td>None</td>
</tr>
<tr>
<td>Injected</td>
<td>None</td>
</tr>
</tbody>
</table>
VII.2. **ANNEX 2: SELECTED ANALYTICAL METHODS FOR THE ANALYSIS OF ECSTASY TABLETS**

**PRESumptive tests (Spot tests)**

**Marquis test**  
[UN, 1995]

1. **Reagent A**  
8-10 drops (approx. 0.25 ml of 37% formaldehyde solution) in 10 ml of glacial acetic acid.

2. **Reagent B**  
Concentrated sulphuric acid.

**or**

2. **Reagent**  
5-6 drops of formaldehyde in 5 ml of sulphuric acid.

**Sulfuric acid test**  
[UN, 1995]

**Reagent**  
Concentrated sulphuric acid (H$_2$SO$_4$ conc.)

**Simon test**  
[UN, 1995]

**Reagent A**  
Dissolve 0.9 g of sodium nitroprusside in 90 ml of water, then add 10 ml of acetaldehyde.

**Reagent B**  
2 g of sodium carbonate in 100 ml water.

**Simon test with acetone**  
[UN, 1995]

**Reagent A**  
Dissolve 0.9 g of sodium nitroprusside in 100 ml of 5% (v/v) aqueous acetone.

**Reagent B**  
2 g of sodium carbonate in 100 ml water.

**Gallic acid test**  
[UN, 1995]

**Reagent**  
Dissolve 0.5 g of gallic acid in 100 ml of concentrated sulphuric acid.
CRYSTAL TESTS [Petter, 1995]

Solutions Water, HOAc 5%, HCl 5%, H3PO4 5%.

Reagents HAuCl₄ (5% in water), HAuBr₄ (0.05 g HAuCl₄, 0.05 g of NaBr, 1 ml water), H₂PtCl₆ (5% in water), H₂PtBr₆ (0.05 g H₂PtCl₆, 0.1 g NaBr, 1 ml water).

THINLAYER CHROMATOGRAPHY (TLC)

System 1 [Huizer et al., 1985]
Plate Silica Gel, 60GF 254 (Merck).
Eluent Toluene : acetone : ethanol : ammonia 25% (45 : 45 : 7 : 3).
Visualisation 1. UV light at 254 nm.
2. Acidified potassium iodoplatinate reagent (0.25 g of platinic chloride and 5 g postassium iodide up to 100 ml with H₂O).

System 2 [Huizer et al., 1985][UN, 1995]
Plate Silica Gel, 60GF 254 (Merck).
Eluent Cyclohexane : toluene : diethylamine (75 : 15 : 10).
Visualisation 1. UV light at 254 nm.
2. Ninhydrin reagent (0.1 % solution in isopropanol).
3. Acidified potassium iodoplatinate reagent (0.25 g of platinic chloride and 5 g postassium iodide up to 100 ml with H₂O).

System 3 [Kala and Madej, 1997][UN, 1995]
Plate Silica Gel, 60GF 254 (Merck).
Eluent Saturation in conc. NH₃. Acetone : methanol (4 : 6). or Methanol : conc. NH₃ (100 : 1.5).
Visualisation 1. 0.03 % fluorscamine in acetone and UV light at 254 nm.
2. 10 % ninhydrin in ethano, sprayed and heated 100°C for 10 min.
3. Acidified potassium iodoplatinate reagent (0.25 g of platinic chloride and 5 g postassium iodide up to 100 ml with H₂O).
HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC)

**HPLC method**  
[Lambrechts and Rasmussen, 1985]

**Instrument**  
SP 8700, Spectra-Physics.

**Injection**  
20 µl sample loop.

**Columns**  
C18 Spheri-5 Brownlee Labs MPLC™ cartidges.

- *Guard column* 30 x 4.6 mm I.D..
- *Analytical column* 100 x 4.6 mm I.D..

**Mobile phase**  
Acetonitrile – water gradient.

Linearly from 35 to 100 % acetonitrile in 15 min, isocratic 100 % acetonitrile for 3 min.

**Flow-rate**  
1 ml/min at ambient temperature.

**Detection**  
HP 1040 A Diode Array UV Detector. (at 254 and 220 nm).

---

GAS CHROMATOGRAPHY (GC)

**SKL method**  
[Jonson, 1994]

**Instrument**  
Hewlett Packard HP 5890.

**Injection**  
Autosampler HP 7673.

Splitless mode.

*Temperature* 250°C.

**Column**  
Capillary column, HP UPC, 25 m x 0.20 mm I.D..

Stationary phase SE-54, film thickness 0.33 µm.

**Carrier gas**  
Helim.

*Flow* 30 cm/s.

**Oven temp.**  
100°C (½ min), 12°C/min, 240°C (5½ min), 15°C/min, 300°C (10 min).

**Detection**  
FID Detector.

*Temperature* 310°C.
**FSS method**  
[King et al., 1994]

**Instrument**  
Hewlett Packard HP 5890.

**Injection**  
Autosampler HP 7673A.  
Splitless mode, 2 µl injection.  
*Temperature* 250°C.

**Column**  
Capillary column, BP5, 25 m x 0.20 mm I.D..  
Stationary phase microm BP-5, film thickness 0.25 µm.

**Carrier gas**  
Helim.  
*Flow* 2 ml/min.

**Oven temp.**  
110°C, 15°C/min, 200°C, 2°C/min, 208°C, 10°C/min, 300°C (5.8 min). Total time 25 min.

**Detection**  
FID Detector.  
*Temperature* 310°C.

---

**IPS method**  
[Guéniat et al., 1997]

**Instrument**  
GC Perkin Elmer Autosystem.

**Injection**  
Autosampler.  
Split mode, 50 : 1.  
*Temperature* 290°C.

**Column**  
Capillary column, DB1, 30 m x 0.25 mm I.D..  
Stationary phase DB-1, film thickness 0.25 µm.

**Carrier gas**  
Helium.  
*Flow* 1 ml/min.

**Oven temp.**  
150°C (1 min), 8°C/min, 250°C, 6°C/min, 320°C.

**Detection**  
FID Detector.  
*Fluxes* H2 (45 ml/min), Air (450 ml/min).  
*Temperature* 330°C.
FAST GAS CHROMATOGRAPHY (FAST-GC)

*NBI method* [Sippola and Kärkkäinen, 1998]

**Instrument** HP 5890 Series.

**Injection** Autosampler HP 7673.
Split mode, 135 : 1.

**Temperature** 280°C.

**Column** Capillary column, HP5, 10 m x 0.10 mm I.D..
Stationary phase microm HP-5, 5% diphenyl dimethyl silicone,
film thickness 0.17 µm.

**Carrier gas** Hydrogen.

**Flow** 250 kPa, 57 cm/s.

**Oven temp.** 170°C, 35°C/min, 320°C (5 min).

**Detection** FID Detector.

**Temperature** 330°C.

CAPILLARY ZONAL ELECTROPHORESIS (CZE)

*IPS method* [Esseiva et al., 1997]

**Instrument** Hewlett Packard HP 3D CE.

**Injection** Pressure injection, 50 mbar, 1 s.

**Column** HP fused silica column, extended path 56 cm x 50 µm.

**Separation**

- **Current** 30 µA.
- **Field strength** 465 V/cm.

**Buffer** 50 mM NaH2PO4 and 50 mM H3PO4, at pH 2.35.

**Oven temp.** 30°C.

**Detection** UV-DAD Detector, at 214 nm.
### VII.3. ANNEX 3: LIST OF RECORDED IMPRINTS FROM JANUARY 1997 TO AUGUST 2000

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*Table VII.3.1.: Imprints from January 1997 to August 2000.*
VII.4. **ANNEX 4: THE THREE-LETTER SYSTEM FOR THE CODIFICATION OF THE TABLET SHAPE**

The three-letter code was given in chapter III.2.

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*Table VII.4.1: The three-letter system for the codification of the tablet shape.*

An example.

*Table VII.4.2: Example of a shape codification.*