Science Title - **Detectives with Forensics**

Summary - The different types of forensics science and how they are used in real life situations (Detectives)

The different forensics:

- Forensic Accounting / Auditing
- Computer or Cyber Forensics
- ***<u>*Crime Scene Forensics</u>***
- Forensic Archaeology
- Forensic Dentistry
- Forensic Entomology
- Forensic Graphology
- Forensic Pathology
- Forensic Psychology
- Forensic Science
- Forensic Toxicology

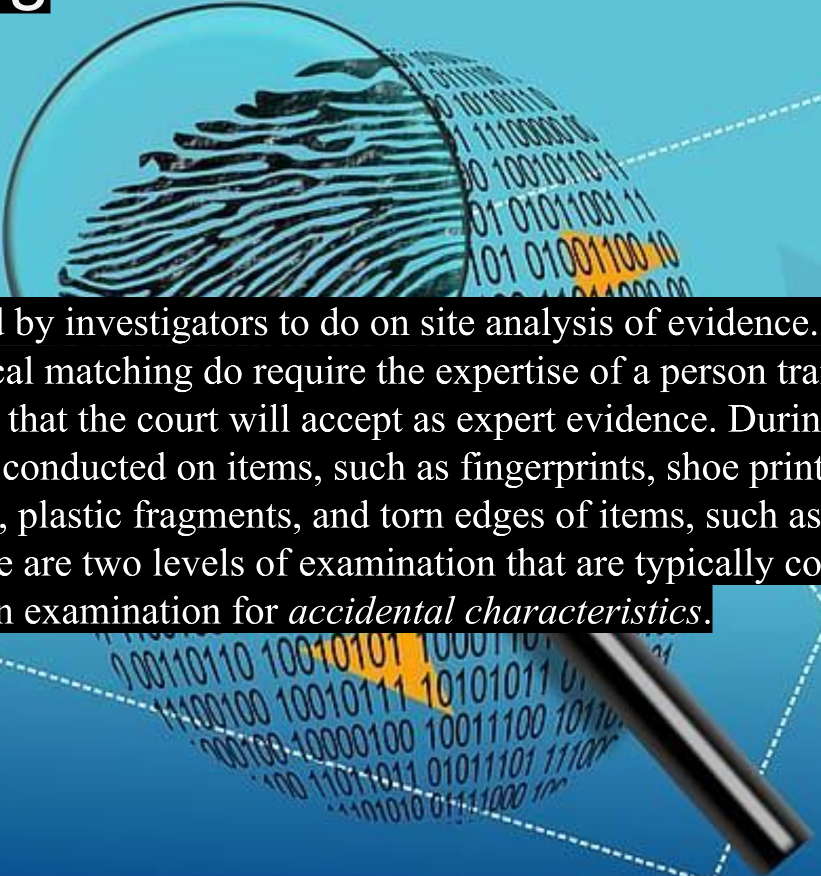
<u>*This is the main one we will be focusing on</u>

Crime Forensic types:

Crime scene investigations document and gather any physical evidence found at a crime scene in order to solve a crime or determine whether a crime has taken place. This kind of investigation also includes the analysis of what investigators collect to ensure the evidence is credible and relevant. There are a wide range of crime scene investigators like ballistics experts, who study the trajectory of ammunition and match bullets to potential firearms, and odontologists, who specialize in teeth and bite-marks to identify missing persons or victims of mass disaster.

1. Physical Matching
2. Fingerprint Matching
3. Hair and fibre analysis
4. Ballistic Analysis
5. Blood Spatter Analysis
6. DNA Analysis
7. Forensic Pathology
8. Chemical Analysis
9. Forensic Anthropology
10. Forensic Entomology
11. Forensic Odontology
12. Forensic Engineering
13. Criminal Profiling
14. Geographic Profiling
15. Forensic Data Analysis
16. Forensic Document Analysis
17. Forensic Identification Sections
18. Crime Detection Laboratories

Physical Matching



Physical matching can be used by investigators to do on site analysis of evidence. That said, the more sophisticated aspects of physical matching do require the expertise of a person trained in the techniques to form and articulate an opinion that the court will accept as expert evidence. During a crime investigation, physical matching is typically conducted on items, such as fingerprints, shoe prints, tire prints, glove prints, tool impressions, broken glass, plastic fragments, and torn edges of items, such as paper, tape, or cloth. In these physical matchings, there are two levels of examination that are typically considered; an examination for *class characteristics* and an examination for *accidental characteristics*.

Level One — The Examination of the Item for Class Characteristics

Determining class characteristics takes place in relation to items, such as shoe prints, tire prints, glove prints, and tool impressions. At the first level of examination, these items can be classified and sorted based on type, make, model, size, and pattern. For example, if a shoe print is found at the scene of a crime and is determined to be a left shoe of a size 9, Nike brand, Air Jordan model, running type shoe with a wavy horizontal sole pattern, these class characteristics collectively provide a description of the suspect’s shoe based on five defined descriptors. In turn, these class characteristics may allow the investigators to narrow their focus to suspects having that class description of shoe. It is not a positive identification of the shoe to any particular suspect, but it does allow the potential elimination of suspects who wear different sizes, brands, and sole patterns of running shoe.

Level Two — Accidental Characteristics

Accidental characteristics are the unique marks and features that develop on any item resulting from wear and tear. Looking back at the Nike Air Jordan Running Shoe, to make a positive match of a suspect’s shoe to the impression found at the crime scene, the crime scene impression would be examined for nicks, gouges, and wear patterns typically present on a worn shoe. These features would then be compared to a rolled impression of a suspect’s shoe, and if the same nicks, gouges, and wear patterns could be shown in all the same locations on the suspect’s shoe, a positive match could be made. Finding a suspect in possession of a shoe, a tire, or a tool that is a positive match to an impression at the criminal event is a powerful piece of circumstantial evidence. With items, such as broken glass and plastic fragments, the process of physical matching requires significantly greater levels of expertise. At Level One, these items are first matched for general characteristics, such as material colour and thickness; however, the process for making the comparison of broken edges requires microscopic examination and photographic overlay comparison of broken edge features to demonstrate a positive match.

Fingerprint Matching

The forensic science of fingerprints has a longstanding history in policing. Fingerprints have been accepted as being individually unique to each person. The courts frequently accept positive fingerprint matches conducted by an expert witness, as proof of identity beyond a reasonable doubt. Prior to the modern advent of DNA analysis and biometric scanning technologies for positive identification, fingerprints and dental record x-rays were the only truly positive means of making a conclusive identification.

Fingerprints are unique patterns of lines and ridges that exist on the areas of our hands and fingertips, known as the plantar surfaces. These unique patterns have been classified in categories and features since the late 1800’s. The various categories and features allow each digit of a person’s fingers to be catalogued in a searchable system or database. These unique categories and features do not change throughout a person’s life, unless they are subjected to damage through physical injury or intentional abrasion. The impressions of our fingerprints are often left on items we touch, thus transferring these fingerprint impressions to those surfaces. They are easily made more visible on most surfaces through the application of coloured fingerprinting powder that adheres to the oils left by our fingers. The powder sticking to the oil reveals the image of lines and ridges that make up the fingerprint. It is also possible for a fingerprint impression to be exposed on surfaces, such as plastic, dry paper, or paint through a process of chemical fuming that reacts with the oils of the fingerprint changing their colour, thereby exposing the image. Fingerprints are sometimes also visible when they are transferred to an object because the finger has some foreign material on it, such as ink or blood.

The unique lines and ridges of an unknown fingerprint can be searched in a database of known criminal fingerprints for identification. Today, this type of search is done electronically using a biometric scanning process. For smaller partial prints, identification of a suspect requires sorting through possible suspects and conducting specific searches of print characteristics to make a match. If the person who left the print does not have a criminal record or their fingerprints are not on file, the only way a comparison can be made is to obtain a set of fingerprint impressions from that person. When this is done, the print examination will be conducted by a trained fingerprint expert who will search the print to establish as many points of comparison between the suspect print and the known-print as possible. The location and identification of a suspect’s fingerprint at the scene of a crime, or on some crime-related object, is strong circumstantial evidence from which the court can draw the inference that the suspect is, in some way, connected to the crime. The investigative challenge of finding a suspect’s print is to eliminate other possible ways that the print may have been left at the scene, other than through involvement in the crime.

Hair and Fibre Analysis

As humans, we are constantly shedding materials from our bodies and our clothing. We enter a room and we leave behind strands of hair that fall from our heads, oily impressing of our fingerprints as we touch objects, and fibres of our clothing materials. As we leave a room, we take away hairs from other occupants of the room or fibres from the carpet and furniture adhering to our clothing. This can be used as evidence that isn't very efficient or effective but still helps narrow doen suspects.

The analysis of hair and fibre, although not an exact science, can provide corroborative evidence. Hair samples can be compared taking a shed sample at the crime scene to the hair from a suspect to establish a similarity within a limited degree of certainty. If the hair happens to have been pulled out and still has root tissue, there is a possibility for more positive identification using DNA analysis. Somewhat more identifiable than hair samples, fibre samples can often be narrowed down to make a higher probability comparison using microscopic examination for size, colour, and type between an unknown sample and control sample.

Ballistic Analysis

Given the number of gun-related crimes, the understanding of ballistic analysis is important for investigators. Ballistics is the study of all things that are launched into flight, how they are launched, and how they fly. In most cases, investigators find themselves dealing with several common types of firearms.

1. Handguns as either semi-automatic pistols or revolvers
2. Long rifles that are single shot bolt action, automatic, or semi-automatic
3. Shotguns that are breach loading or chambered pump action

There are techniques in ballistic science that address the unique aspects of firearms and bullets. Because ballistic comparisons seek to determine if a particular gun was the originating source of an unknown bullet or cartridge casing, this examination process is sometimes referred to as ballistic fingerprinting. The analogy being that if a particular gun touched a particular bullet or cartridge-casing, it will leave behind some unique identifiable marks or a ballistic fingerprint.

At Level One, cartridges are classified by the calibre, which is the size of the bullet, the maker of the cartridge, and the primer location; either a centre-fire or a rim-fire cartridge on the cartridge base.

In addition to the ballistic fingerprinting examinations, another area of ballistic science is known as trajectory analysis. The trajectory of a bullet is the path it travels from the time it leaves the barrel of the gun to the point where it finally loses the propulsion energy of the gunpowder and comes to rest. The flight of a bullet can be very short, as in the case of a point blank shooting, where a victim is shot at very close range, or it can be very distant where the target is one mile away or more, as in the case in some sniper shootings. When the bullet is travelling a longer distance, it travels that distance in an arched path or trajectory of travel as it is pulled towards the ground by gravity. When the bullet arrives at its destination, it will have a distinct angle of entry into the target. This angle of entry can sometimes be calculated as trajectory to estimate the geographic location of the originating shot. In cases where a bullet passes through several objects, such as two walls of a house, the trajectory of the bullet can be used to determine where the shooter was located. In cases of drive-by shootings, for example, where several shots are fired, the pattern of trajectories can show if the shooter was moving and, if so, demonstrate the direction of travel.

At Level Two, the more decisive ballistic fingerprint comparisons are often made using the following methods:

1. Striations Matching;
2. Chamber Markings;
3. Firing-Pin Comparison; and
4. Ejector markings.

1. Striations Matching. Bullets fired from either a handgun or long rifle, other than a shotgun, fire a single projectile each time.When fired, this bullet travels down the barrel of the gun and begins to spin because the inside of the gun barrel has been intentionally machined with long gently turning grooves, called rifling. These grooves catch the soft-lead sides of the bullet spinning it like a football, and this spinning makes the bullet travel more straight and true to the target. As a result of these grooves designed into gun barrels, every bullet fired will arrive at its target with markings etched into the bullet material from contact with the grooves in the barrel. These etched markings are call *striations*, and they are uniquely identifiable back to the gun they were fired from. For an investigator, these striations create an opportunity to match the bullet to the gun that fired it. Recovered bullets can be recovered and compared to test bullets fired from a suspected gun.

2. Cartridge Chamber Markings. When a cartridge is loaded into the chamber of a gun, the shiny brass casing comes into contact with the hard steel sides of the chamber. This chambering of the cartridge can leave unique and identifiable scratch marks on the side of the casing. A cartridge casing ejected or unloaded from a weapon and left at the crime scene can sometimes be matched to the suspect gun by comparing these markings.

3. Firing Pin Comparison. When the firing pin of any gun strikes the primer on the bottom of a cartridge, it leaves an indentation mark. This firing pin indentation can sometimes be matched to the firing pin of a suspect weapon. This requires microscopic examination that looks for the unique characteristics of the firing pin that become impressed into the soft metal of the primer when the firing contact happens.

4. Ejector Mechanism Markings. Methods for loading and unloading weapons have evolved considerably due to different gun designs. The simplest guns allow the user to open the breach of the gun exposing the cartridge chamber to manually insert the cartridge and close the breach to make ready for firing. There is no ejector mechanism for these guns, so there will be no ejector marks left on the base of a cartridge when it is unloaded from the weapon.

Blood Spatter Analysis

Blood spatter analysis, also known as blood stain pattern analysis, is a relatively new forensic specialty. The purpose of this analysis is to determine the events of a crime where blood has been shed. This is accomplished through the careful examination of how blood is distributed inside the crime scene. Studies have shown that when blood is released during an attack, certain patterns of distribution can be expected. For instance, a person being struck with a baseball bat will begin to bleed, and blood will be distributed in a droplet spatter pattern in the direction of the strike behind the victim. These droplets of blood will have a direction of travel that will be indicated by the directional slide of each droplet as the bat hits objects in its path. Blood from the victim adhering to the bat can also be distributed when the bat is on the upstroke for the next strike. This blood will be distributed in an upward directional slide pattern, for example, up a wall, onto a ceiling, or behind the attacker. Calculations of how many strikes were made may become evident from the tracking of multiple streams of droplets behind the victim and behind the attacker. Given this developing science, blood spatter analysis can be useful in criminal event reconstruction.

DNA Analysis

DNA, or deoxyribonucleic acid, is a molecule that holds the genetic blueprint used in the development, functioning, and reproduction of all living organisms. As such, it carries the unique genetic information and hereditary characteristics of the cells from which living organism are formed. Except for identical twins, the DNA profile of each living organism is unique and distinct from other organisms of the same species. There are some rare cases where one person may carry two distinct types of DNA, known as Chimera where paternal twin embryo merge during gestation, or in cases where a bone marrow transplant enables the production of the marrow donor DNA in the recipient’s blood. In these rare cases, a person may test for two distinct DNA profiles for different parts of their body.

In human beings, DNA comparison can enable high probability matches to be made between discarded bodily substances and the person from whom those substances originated. Bodily substances containing cellular material, such as blood, semen, seminal fluid, saliva, skin, and even hair root tissue can often be compared and matched back to its original owner with high statistical probabilities of comparison. Sometimes, even very old bodily substances, such as dried blood, dried saliva, or seminal stains, can be analyzed for a DNA profile. The introduction of DNA analysis has allowed investigators for advocates to re-examine historical evidence and exonerate persons wrongfully convicted and imprisoned for criminal offences.

DNA is a very powerful tool for investigators and can be considered anytime discarded bodily material is found at a crime scene. Even very small amounts of material can yield enough material for DNA comparison. Importantly, DNA data-banks of known criminals and unsolved crimes are now becoming well established in North America. When a person is convicted of certain criminal offences, DNA is collected and submitted to these databases.

Forensic Pathology

Forensic Pathology is the process of determining the cause of death by examining the dead body during an autopsy. An autopsy generally takes place in the pathology department of a hospital. In the case of a suspicious death or a confirmed homicide, police investigators will be present at an autopsy to gather information, take photographs, and seize exhibits of a non-medical nature, such as clothing, bullet fragments, and items that might identify the body. These items would include personal documents, fingerprints, and DNA samples.

During an autopsy, a forensic pathologist dissects the body carefully examining, documenting, and analyzing the body parts to determine the cause of death. In the first stage of an autopsy, the pathologist examines the body for external injuries and indicators of trauma that may provide a cause of death. In this first stage of examination, the pathologist will make an estimate of the time-of-death by observing evidence of four common *post-mortem* (after-death) indicators. These are body temperature, the degree of rigor mortis, post-mortem lividity, and progress of decomposition.

Body Temperature

Algor Mortis is the scientific name given to the loss of body temperature after death which can sometimes be used to estimate the time of death. This is a viable technique in cases where the body is being examined within 24 hours following death. This method of estimating time of death can vary significantly dependent upon many possible variables, such as:

- Ambient room temperature being within a normal range of approximately 22° Celsius
- Pre-death body temperature of the victim not being elevated by illness or exertion
- Thickness of clothing that might insulate the body temperature escape
- The temperature and conductivity of the surface the body was located on that could artificially increase or decrease temperature loss

Considering a normal body temperature of 37° Celsius at the time of death, it can be estimated that the body will cool at a rate of 1° – 1.5° Celsius per hour. This calculation is known as the *Glaister Equation*. So, taking an internal rectal temperature and subtracting that from 37° Celsius will provide an estimate of the number of hours that have passed since the time of death. For example, a dead body with a measured temperature of 34° Celsius would provide a time range of 3 to 4.5 hours since the time of death.

Rigor Mortis

Rigor mortis is a term used to describe the stiffening of the body muscles after death. A dead body will go from a flaccid or limp muscle condition to one where all the muscles become contracted and stiff causing the entire body to become constricted into a fixed position. After being in a constricted and fixed position, the muscles eventually become flaccid again. In normal room temperatures, this stiffening of muscles and the relaxing again has a predictable time progression of approximately 36 hours. In this progression, the stiffening of muscles will take approximately 12 hours, the body will remain stiff for 12 hours and will progressively become flaccid again over the next 12 hours.

Stiffening of muscles begins with the small muscles of the hands and face during the first 2 to 6 hours, and then progresses into the larger muscle groups of the torso, arms, and legs over the next 6 to 12 hours. These are general rules; however, the rate of rigor mortis can be different for infants, persons with extreme muscle development, or where extensive muscle activity precedes death, such as a violent struggle.

In determining the time of death in average environmental temperatures, recommended that:

1. If the body feels warm and is flaccid, it has been dead for less than 3 hours
2. If the body feels warm and is stiff, it has been dead for 3 to 8 hours
3. If the body feels cold and stiff, it has been dead for 8 to 36 hours
4. If the body feels cold and is flaccid, it has been dead more than 36 hours

Post-Mortem Lividity

Post-mortem lividity refers to a discoloration or staining of the skin of a dead body as the blood cells settle to the lowest part of the body due to gravity. This discoloration will occur across the entire lower side of a body; however, in places where parts of the body are in contact with the floor or another solid object, the flesh compresses and staining will not occur in that area. The staining is a reddish-purple colouring, and it starts to become visible within 1 hour of death, and become more pronounced within 4 hours. Within the first 4 hours, lividity stains are not fixed and, if the body is moved, the blood products will shift and stain the part of the body that has become lower. In most cases, these stains become fixed between 12 and 24 hours. As such, they can be viewed as an indicator of how the body was left at the time of death. Importantly, if a body is found with post-mortem lividity stains not at the lowest point in the body, it can be concluded that the body has been moved or repositioned after the 12 to 24 hour stain setting period

Decomposition

This is the final indicator a pathologist can look at to estimate the time of death. Sometimes, dead bodies are not discovered in time to use body temperature, rigor mortis, or early lividity indicators to estimate a more exact time of death. In these cases, assessing the progress of decomposition becomes important. Decomposition starts as soon as the body ceases to be alive. Subject to environmental conditions of extreme heat or cold, the readable signs of decomposition will become apparent 36 to 48 hours after death. These signs include bloating of the body and a marbling discoloration of the skin in a spider web pattern along surface blood vessels. As the body continues to decay, the skin surface will open and body fluids will begin to seep out. In advanced stages of decomposition, the body is often no longer identifiable by facial recognition, and DNA testing or dental records become the tools to determine identity. At very advanced stages of decomposition, flies and maggots begin to emerge, and the number of life cycles of the maggot-to-fly can be estimated by a forensic entomologist to provide the amount of time that has passed since these insect life cycles began. Once these preliminary examinations have been made, the pathologist will cut the corpse open to conduct a detailed internal examination of each organ to look for signs of trauma, disease, or external indicators that might explain the cause of death, such as water in lungs or toxins in blood.

Chemical Analysis

There are a wide range of chemicals and usages that can be used in the commission of a crime or found at the scene of a crime. In addition to general chemical analysis, there are several sub-areas for analysis in cases of:

- Accelerants used in the crime of arson;
- Explosive analysis in cases of conventional crimes and terrorism;
- Toxic chemicals and biological agents used in cases of murder, industrial negligence, and terrorism;
- Drug analysis in the cases of trafficking and drug overdoses;
- Gunshot residue analysis; and
- Analysis and chemical matching of paint transfer in cases of hit and run motor vehicle crashes.

Forensic Archaeology

Relatively new in the forensic world, forensic archaeology is the use of archaeological methods by experts to exhume crimes scenes, including bodies. These forensic experts are trained to methodically excavate and record their dig. They document the recovery of artifacts (evidence), such as human remains, weapons, and other buried items, that may be relevant to the criminal event. Forensic archaeologists will often work in concert with other forensic experts in DNA, physical matching, forensic entomology, and forensic odontology in the examination of evidence.

Forensic Entomology

Forensic entomology is a very narrow field of forensic science that focuses on the life cycle of bugs. When a dead body has been left out in the elements and allowed to decompose, the investigative challenge is not only to identify the body, but to establish the time of death. Once a body has decomposed, the process of determining time of death can be aided by a forensic entomologist. As discussed in a previous chapter, these experts look at the bugs that live on a decomposing body through the various stages of their life cycle. From these life-cycle calculations, scientists are sometimes able to offer and estimate relative time of death.

Topic 11: Forensic Odontology

To paraphrase the description provided by Dr. Leung (2008), forensic odontology is essentially forensic dentistry and includes the expert analysis of various aspects of teeth for the purposes of investigation. Since the advent of dental x-rays, dental records have been used as a reliable source of comparison data to confirm the identity of bodies that were otherwise too damaged or too decomposed to identify through other means. The development of DNA and the ability to use DNA in the identification of badly decomposed human remains has made identity through dental records less critical. That said, even in a badly decomposed or damaged corpse, teeth can retain DNA material inside the tooth, allowing it to remain a viable source of post-mortem DNA evidence.

Beyond the identification of dead bodies, forensic odontology can sometimes also provide investigators with assistance in confirming the possible identity of a suspect responsible for a bite mark. This comparison is done by the examination and photographic preservation of the bite mark on a victim or an object, and the subsequent matching of the details in that bite mark configuration to a dental mould showing the bite configuration of a known suspect's teeth. Although bite mark comparison has been in practice for over fifty years there remain questions to the reliability for exact matching of an unknown bite mark to a suspect

Forensic Engineering

Forensic engineering is a type of investigative engineering that examines materials, structures, and mechanical devices to answer a wide range of questions. Often used in cases of car crashes, forensic engineers can often estimate the speed of a vehicle by examining the extent of damage to a vehicle. They can also match damage between vehicles and road surface to determine the point of impact and speed at the time of impact. Many police agencies now have specialized traffic personnel trained in accident analysis and accident reconstruction. These officers utilize a variety of forensic engineering techniques to examine and document the dynamics of car crashes to establish how and why a crash occurred.

In cases of building collapses, forensic engineers can conduct analyzes to determine the cause of a structural failure and, in the case of an intention explosion, such as in acts of terrorism, this can point to the location of the planted explosive device. The investigative possibilities for forensic engineering are too extensive to elaborate here, but if damage to a building, an object, or a piece of equipment poses an investigative question, the tools of forensic engineering should be used to seek answers.

Criminal Profiling

Criminal profiling, also referred to as psychological profiling, is the study of criminal conduct to develop the most likely social and psychological profile of the person who may have committed the crime based on the actions of known criminals who have committed that same type of crime in the past. Criminal profiling draws on information from many sources, including historical criminal statistics of known criminals. Additionally, other information is collected about violent criminals and their *modus operandi*. This kind of information can shed light on details, such as preferences for luring victims, taking trophies, abduction methods, bondage preference, torture methods, means of killing, and displaying a dead body after death. With information and specific data collected from a wide assortment of offenders, psychological profilers work with investigators to examine the details of a criminal investigation, and, based upon the known historical criminal conduct data, they determine probable descriptors and characteristics that might be expected in a current suspect's profile.

For investigators, this kind of profiling can be helpful in focusing the investigation on the most likely persons. As an extension of these profiling techniques, a database known as *Violent Crime Linkage Analysis System (ViCLAS)* has been in place in Canada since the 1990s. This system documents the criminal conduct of convicted violent offenders and sex offenders, as well as certain unsolved cases, with a goal of documenting crime types and criminal conduct into a searchable database where unsolved crimes can be linked to offenders with matching profiles. According to the ViCLAS system web page, "Since the implementation of ViCLAS across the country, the database continues to swell with cases. As of April 2007, there were approximately 300,000 cases on the system and over 3,200 linkages have been made thus far" (Royal Canadian Mounted Police, 2015). Criminal profiling provides a valuable tool for sorting and prioritizing suspects identified for further investigation. In some cases, a new suspect may even be identified through the existing data within the ViCLAS database.

Geographic Profiling

Geographic profiling is similar to psychological profiling in that it seeks to focus on the possible conduct of an unknown criminal based on the data collected from the known past criminal conduct of others. Unlike psychological profiling, geographic profiling is focused specifically on where a suspect might reside relative to the location where his or her crimes are currently being committed.

In the late 1980's, police Detective Inspector Kim Rossmo developed a mathematical formula that began the evolution in the new forensic science of geographic profiling. Dr. Rossmo validated his mathematical formula from his observation that criminals generally seemed to live within an identifiable proximity to the chosen locations where they committed their crimes. Applying this method, when a criminal is suspected of committing a series of offences, it is possible to have the locations of those offences examined by a geographic profiler to estimate where that suspect most likely resides. This assessment can be helpful in searching for and identifying new suspects by prioritizing suspects based on the location of their residence relative to the identified area with the highest probability for a suspect to be found.