EVALUATING THE UTILISATION OF INTEGRATED BALLISTIC IDENTIFICATION SYSTEM (IBIS) IN THE INVESTIGATION OF FIREARMS-RELATED CRIMES IN PRETORIA

By

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Submitted in fulfilment of the requirement for the degree of

MASTER OF ARTS

In the subject

CRIMINAL JUSTICE

At the

UNIVERSITY OF SOUTH AFRICA

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OCTOBER 2021

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I declare that this dissertation is my own work and that all the sources used or quoted are indicated and acknowledged by means of a complete reference. The study was done under the supervision and guidance of Mr R J. Mokwena of the University of South Africa.

Date: 01/10/2021

DEDICATION

To both my late father “Bro” Thami and my daughter Esona, this is for you in heaven, Dad. Though you left very early in my life; your teachings remained with me and kept me going through all my hardships. To my mother, you’ve been my pillar of strength, raising eight children alone, unemployed, with nothing, has taught me that strong women don’t have attitudes: they have standards and boundaries. Womandla to you Sukude, Mkhondwane.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation, gratitude and thanks to the following whom without their support, this study wouldn't have been achieved:

- God almighty, the creator of all for the grace and favour upon my life.
- To my family, Babalwa, Lwanda, Aya and Ithalomzi for support and giving me the opportunity to realise my dream.
- My supervisor, Mr R J. Mokwena for guidance, support and encouragement over the years of my studies.
- SAPS management for giving me the opportunity and granting permission to conduct my research.
- The participants of Forensic Science Laboratory (Ballistics section) for their cooperation and assistance during my research.
- Special appreciation to Lt Col Matshingana and Ms Nkhensani Maluleke for their encouragement and support during difficult time of my studies when I thought of giving up.
- Lastly, to UNISA funding office for granting me the financial assistance.

ABSTRACT

The rise in firearms-related crimes which involve a repeated use of firearms by criminal syndicates in South Africa, has become a huge concern and has reached alarming levels. The aim of this research was to evaluate the role played by SAPS Forensic Science Laboratory in use of the integrated ballistic identification system (IBIS) in the investigation of firearms-related crimes, with the objectives to understand what is IBIS, and the purpose therefore to evaluate and understand the processes employed using IBIS in the investigation of firearms hence the following questions were answered: What is the meaning of IBIS and how is it used in the investigations of firearms?

The researcher evaluated how forensic analysts are currently examining exhibits (firearms, cartridge cases and bullets) with the use of IBIS and highlighted the inefficiencies that hinder effective use of the IBIS system. A qualitative approach was adopted in conducting the study, where interviews, documents and personal experiences were used as data collection methods. The researcher made use of an empirical design, as the information available on the research topic was limited. The empirical design, together with a qualitative research approach, allowed for real-life observations. The researcher used purposive sampling to select ballistic experts with experience and knowledge of IBIS and firearms-related investigations. With limited time available for the research, purposive sampling is somewhat less costly, more readily accessible, more convenient and selects only those individuals that are relevant to research design.

In terms of the use of IBIS in the investigation of firearms-related crimes, the research found that IBIS was not sufficiently utilised in the investigation of firearms-related crimes. Though useful and efficient when used effectively, there are inefficient processes impeding the use of the IBIS system to its full potential.

Recommendations are that Forensic Science Laboratory (FSL) Ballistics Section management optimally utilise IBIS in the investigation of firearms-related crimes. This can be achieved through further training of the ballistic analysts and the development of new management procedures to be implemented specifically to govern the operation of the system.

Key Terms: South African Police Service, FSL, United State Federal Bureau of Investigation, Firearm control regulations, Firearm examination, Forensic Technology Inc., Integrated Ballistic Identification Systems.

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ABBREVIATIONS

AAA	Arms and Ammunition Act
ABIS	Automated Ballistic Identification Systems
ATF	Bureau of Alcohol, Tobacco, Firearms and Explosives
CMS	Consecutive Matching Striae
CRC	Criminal Record Centre
CI	Crime Intelligence
DAS	Data Acquisition Station
DPCI	Directorate for Priority Crime Investigation
FBI	United State Federal Bureau of Investigation
FCA	Firearm control Act
FSL	Forensic Science Laboratory
FTI	Forensic Technology Inc.
HNO3	Nitric acid
HoD	Head of Department
JCPS	Justice, Crime Prevention and Security Cluster
IBIS	Integrated Ballistics Identification System
ICT	Information Communication Technology
IDP	Integrated Development Plan
IGR	Intergovernmental Relations Framework
IPID	Independent Police Investigative Directorate
MPS	Metropolitan Police Service
NCPS	National Crime Prevention Strategy
NDP	National Development Plan
NQF	National Qualifications Framework
NIBIN	National Integrated Ballistic Information Network
NI	National Instruction
NIST	National Institute of Standards and Technology
SA	South Africa
SAPS	South African Police Service
SAS	The Systems Analysis Station
SITA	State Information Technology Agency

SOP	Standard Operating Procedure
RSA	Republic of South Africa
UNISA	University of South Africa
UNODC	United Nations Office on Drugs and Crime
WWW	World Wide Web

CHAPTER 1

GENERAL ORIENTATION

1.1 INTRODUCTION

Before 1998, the United States Federal Bureau of Investigation (FBI) and the United States Department of Justice's Bureau of Alcohol, Tobacco, Weapons and Explosives (ATF) developed separate imaging systems and databases to analyse and store ballistic pictures (Gale, 2005). The FBI system was referred to as Drugfire and the ATF system became integrated ballistic identification system (IBIS). In 1993, ATF acquired IBIS from its developer, Forensic Technology, Inc. (FTI) in Montreal, Canada. The project started in 1990 and became IBIS so that law enforcement professionals would use ballistic digital computer images and support criminal laboratories with an increasing number of firearms crimes (Boesman & Krouse, 2001). Since the early 1920s, in criminal cases, forensic ballistic evidence has been used to analyse almost all forms of crime, using various methods for various crimes (Dack, 2014:15).

The researcher decided to carry out this research, considering the high rate of firearms-related crimes in South Africa. The researcher was a police officer with 17 years of service and has first-hand experience in attending crime scenes involving the use of firearms. With more than four years of experience as a forensic analyst at the South African Police Service FSL in Pretoria, the researcher assessed the use of IBIS in the investigation of firearms-related crimes, particularly in Pretoria, in order to understand the role, responsibilities and challenges of the ballistic section.

Forensic science is becoming more advanced every day, with many countries turning to science to solve their crimes; IBIS is used as a forensic tool to link exhibition to crime. Van Rooyen (2004:7) also stated that the use of science as the method of solving crime is "forensic investigation." IBIS is a computerised system used to obtain and store pictures of cartridges and/or unidentified fired bullets and those fired from known firearms (Thompson, 2011). When a cartridge is fired from a firearm, the firearm leaves unique marks on bullets and cartridge cases which, when examined by forensic scientists, may be linked to a specific firearm used to commit a crime. By analysing these ballistics marks, firearm examiners are in a position to link a bullet and/or cartridge case to a firearm. Thus, the focus on this study was on evaluating the current processes employed using IBIS during firearm investigation.

1.2 PROBLEM STATEMENT

According to Kumar (2014:64), the first step in conducting scientific research is to clearly identify the particular problem to be addressed. Leedy and Ormrod (2013:28) argued that the problem should address an important question, such that the answer could actually make a difference in some way, and it should lead to new ways of thinking, suggesting possible applications, or paving the way for further research in the field.

The South African Police Service (SAPS) derives its powers and functions from Section 205 of the Constitution of the Republic of South Africa, and from the South African Police Service Act of 1995. This legislation is intended to control the activities of the police service, which is to combat crime and to promote a safe and secure environment for all people in South Africa. The FSL of the SAPS Forensic Science Division is responsible for forensic investigations. IBIS is an acronym for the Integrated Ballistics Identification System, an electronic database used to store firearms-related evidence used by the FSL. This system was introduced by Forensic Technology Inc. (FT) in South Africa in 1997 (Hosken, 2007).

There is a rise in firearms-related crimes in South Africa (SAPS, 2018). These crimes involve the repeated use of specific firearms, conditions that are ideal for IBIS technology. SAPS have four professional Forensic Science Laboratories across the country, with headquarters in Pretoria. FSL in Pretoria is the largest of the laboratories and responsible for five provinces: Free State, Mpumalanga, Limpopo, North West and Gauteng. Through experience working at ballistics section as an IBIS analyst, the researcher observed that the use of IBIS is impeded by inefficient processes at FSL Headquarters in Pretoria. After a case has been examined by a ballistics analyst, the final stage is IBIS acquisition which is not finalised by the examiner; instead, the case is transferred to IBIS subsection for acquisition of exhibits and/or tests. This has resulted in a large number of cases waiting to be finalised and subsequently contributes to delays in acquiring these exhibits into IBIS system and possible generating matches and linking cases.

1.3 AIM OF THE RESEARCH

The main goal of research is to find the truth that is obscured and not yet found (Kothari, 2004:15). The aim of the research must be carefully established once the research problem has been identified as it represents the sole objective of the overall effort (Leedy & Ormrod, 2010:48).

The aim of this study was to evaluate existing firearm investigative processes using IBIS in the investigation of firearms-related crimes.

1.4 OBJECTIVES OF THE RESEARCH

De Vos, Strydom, Fouché and Delport (2011:108) stated that the research objectives set out in more detail the specific research topics or issues that the project plans to investigate, building on the main theme set out in the research objective. Goddard and Melville (2013:1) further refer to research objectives as "answering questions" which have not been answered or which are intended to create what does not currently exist. The objectives of this research were to:

- Understand the meaning of IBIS.
- Understand how the system is used in the investigation of firearms.
- Determine best practices to be used to improve the use of IBIS and make recommendations.

1.5 PURPOSE OF THE RESEARCH

Welman and Kruger (2002:18) argued that the purpose of research is to define, explain and, as a result, predict or control human behaviour, its organisations and/or events. Denscombe (2010:26) further explained that research can serve many purposes, such as explaining things, describing problems, solving practical problems and improving procedures. The purpose of this research was therefore to evaluate and understand the processes employed using IBIS in the investigation of firearms at FSL, with a view to identifying strengths and limitations, and to consider how these issues could be improved (Denscombe, 2002:25).

1.6 RESEARCH QUESTION(S)

Creswell (2014) stressed the importance of clarifying a purpose statement to help guide the research questions. Leedy and Ormrod (2010:56) indicated that research questions are formulated in an effort to establish new facts, and that this is a good way to determine which methods will be used to collect data (Flick, 2011:90). De Vos et al. (2011:352) encouraged researchers to follow a logical sequence in a study and limit the research questions. For the purpose of this research, the following questions must be answered:

- What is the meaning of IBIS?
- How is IBIS utilized during firearm investigations?

1.7 KEY THEORETICAL CONCEPTS

According to Leedy and Ormrod (2005:119), key concepts are defined in order to avoid any misunderstanding. The process of conceptualising is to envision exactly what we mean when we use particular terms (Maxfield & Babbie, 2011:123; Bachman & Schutt, 2011:84). Gomm (2008:25) also made it clear that "scientifically plausible researchers are often asked to identify concepts that capture the real meaning of what research is all about". The words are representative of the things being researched about.

The following key concepts have been identified in this research to prevent any misunderstanding.

1.7.1 Firearms identification

Giannelli (2007:2) defines "identification of firearms" as a "forensic science discipline that identifies a bullet, cartridge or other ammunition component as being fired by a firearm to the exclusion of all other firearms".

1.7.2 Evidence

Joubert (2001:331) explained that evidence is the source of facts or factuality. It must contain "all the information and material submitted to the court by the parties concerned in order to enable the presiding officer to judge and settle the dispute".

1.7.3 Integrated Ballistics Identification System (IBIS)

IBIS is a computerised system used to acquire and store the images of fired bullets and cartridge cases of questioned origin and those fired from known firearms, according to Hill (2018).

1.8 VALUE OF THE RESEARCH

The researcher understands that SAPS, like many other law enforcement agencies across the globe, relies upon IBIS to assist in solving firearms-related crimes. This research is of significance because it aims at highlighting the inefficiencies that hinder effective use of the IBIS

system. This will assist the organisation to develop more efficient processes to utilise the system more effectively. The research will add more literature pertaining to what IBIS entails. The South African public and criminal investigators will benefit, and the research can be used by researchers as a basis for future research. It can also be used as a secondary resource by future researchers.

The importance of research is defined by Welman and Kruger (2002:256) as “demonstrating a measure of research skill” or problem-solving capacity and, to a lesser degree, “contributing to the body of knowledge” in a science field. In addition, De Vos et al. (2011:107) and Denscombe (2010:24) alluded to the need to be able to use studies for practical purposes and indicated that they should be useful for the intended target audience. It is anticipated that SAPS can benefit from the unique nature of this study by considering and implementing the research findings.

Taking into account the study findings and appropriate effective mechanisms to resolve the inefficiencies are in place, would improve the investigation of firearms-related crimes, thus benefiting criminal justice as a whole. Study may be used to create educational materials for investigators and forensic experts and enhance investigative skills. If FSL standards increase, become more detailed and educated, South African society will benefit. The research could result in changes in the public’s attitude towards FSL. As the results will lead to identifying the inefficiencies hindering the successful use of the IBIS system, the SAPS image will also improve and suggestions will be made about how to address the identified challenges. The results will also allow the public to understand what IBIS is all about and the problems that ballistic analysts face. Finally, UNISA and the wider academic community will be able to access the results of the study. For both future curriculum creation and as a guide for students and scholars, it can be useful.

1.9 PRELIMINARY LITERATURE REVIEW

It is important to review literature sources in relation to the research topic and the research problem. As an integral part of the study process, Kumar (2014:48) emphasised the literature review. Guthrie (2010:28) further pointed out that literature is searched for appropriate publications to be reviewed to help set the framework for the research topic and to describe it. The researcher conducted a comprehensive literature review of the use of IBIS in firearm crime investigation to determine what was written or published. Welman, Kruger & Mitchell, (2005:38) stressed the importance of a wide-ranging review of literature on research topics, problem and

questions, but no literature on the same topic as current study was found (Leedy & Ormrod, 2013:51).

Sources of literature help to gain a clear understanding of and insight into previous research performed, according to Creswell (2009:26) and Welman et al. (2005:41). The authors also pointed out that the most productive way to review existing literature is to search for keywords and terms that specifically relate to and explain the problem of study, research questions and the purpose of their research (Creswell, 2009:29; Welman et al., 2005:40). This allows for finding a wide variety of sources of literature with specific data that could be used. Appropriate keywords and terms derived from the topic were generated in this study and the research problem, by reviewing dictionaries, reading books on the topic concerned, and also from the researcher own field experience.

Following this approach, the researcher used primary, secondary and tertiary sources (Welman et al., 2005:41):

- Primary sources: forensic analysis, forensic ballistics and IBIS, as well as both existing and unpublished sources and manuscripts (Welman et al., 2005:41).
- Secondary sources: forensic investigation books and journals related to the research issue.
- Tertiary sources: dissertations and theses from researchers in the field of forensic investigation.

In order to assist me with some useful knowledge related to the topic, literature was checked for information on these concepts.

1.10 RESEARCH DESIGN AND APPROACH

1.10.1 Design

According to Kumar (2014:122), the research design includes a road map that the researcher decides to follow during the research journey to find answers to the research questions and should be as valid, objective, accurate and economical as possible. An evaluation of the use of IBIS in the investigation of firearms-related crimes is the topic of this research. Maxfield and Babbie (2011:6) pointed out that the design of empirical research produces knowledge based on experience or observation. In this study, the researcher used an empirical research design to evaluate and explore the use of IBIS in the firearm investigation. The research method included interviews using semi-structured questions, literature reviews and personal experience. The

researcher identified FSL ballistic analysts involved in the firearm investigation as research participants, thus gaining knowledge from them through their experience.

The aim of this research was to provide an accurate and valid representation of the phenomenon, i.e. to explore how IBIS is used in the investigation of firearm crimes. The purpose of this research was therefore exploratory.

1.10.2 Approach

Fouché and Delport (2011:63) noted that qualitative and quantitative methods are the two well-known approaches in studies. As the research is exploratory, qualitative exploratory research is described by Leedy and Ormrod (2014:141) and Skorupski (2005:427) as a research methodology where a researcher explores the complexity of events in natural settings. Qualitative study includes the use and compilation of a variety of empirical material from a relatively limited number of individuals through interviews, literature and personal experiences as the aim is to gather rich and detailed information that explains events and situations (Skorupski, 2005:427). Therefore, the methodology made it possible to integrate the views of the people involved in the investigation of firearms crimes regarding their experiences in the use of IBIS.

1.11 TARGET POPULATION AND SAMPLING

1.11.1 Target population

Welman and Kruger (2002:46) described the population as the study of objects made up of "people, organisations, human products and events or the conditions under which they are exposed". This is supported by Dantzker and Hunter (2012:198) who stated that the population is the whole group or class of potential participants from which information is needed.

Forensic analysts linked to FSL Ballistics section. The researcher narrowed the population and used a target population, described by Creswell (2013:142) as "a group of people with the same characteristics". Forensic analysts attached to ballistics in Pretoria, Durban, Port Elizabeth and Cape Town were part of the population for this research. Although the primary focus was FSL Pretoria, to broaden literature search, the researcher included other regions because of a lack of availability of participants due to the Covid-19 pandemic.

1.11.2 Sampling

According to De Vos et al. (2005:194), a sample comprises elements of the population which are actually included in the study. Samples are drawn because researchers want to understand the population they are drawn from and explain the characteristics of the population.

In the research, the researcher used non-probability sampling in the form of purposive sampling (Leedy & Ormrod, 2005:211). The purposive sampling method provided researcher with the opportunity to handpick participants who were suitable for the research. The “purposive sampling method” allowed researcher to intentionally find units of analysis in such a way that the sample obtained could answer the research question (De Vos et al., 2005:69).

The researcher selected ballistics experts with experience and knowledge of IBIS and firearms-related investigations. The ballistics section consists of 96 analysts and I selected experts with a minimum of four years’ experience in ballistics analysis. In determining the sample size of interview participants, the researcher included forensic analysts who were experienced, knowledgeable and best placed to answer questions on firearms-related crimes.

1.12 DATA COLLECTION

Maxfield and Babbie (2005:209) pointed out that the value of the research depends on how the data is collected. The data is collected according to the type and purpose of the research. Mouton (2001:98) indicated that the most widely used data collection methods in qualitative research include interviewing, observation and documentary sources. In this study, the researcher used interviews, a literature review and personal experience as data collection techniques (McMillan & Schumacher, 2001:42).

1.12.1 Literature

All available research literature on a subject or topic is referred to as a literature review (Flick, 2011:196). Leedy and Ormrod (2014:51) stated that there are many benefits in doing an extensive literature review. In order to find the literature for the study, extensive research was conducted on both national and international literature, such as books, journals, course materials, theses and dissertations, government publications and various search engines via the World Wide Web (WWW) to assist in the retrieval of data from relevant websites. The aim of research, as well as research questions, served as a guideline for obtaining relevant research literature.

Mouton (2001:87) emphasised the importance of conducting a literature review in order to establish existing literature in a specific field of study. Preliminary findings showed that there is information on the topic but not on the specific topic of this study. In order to address the research aim and research problem in this study, the researcher used keywords that included the following concepts:

- Integrated Ballistic Identification System;
- the use of IBIS;
- Identification of firearms;
- Examination of Firearm;
- Match Point; and
- Comparison microscopic.

Locally, limited literature was available on the specific research questions or related to the same topic, although there was a reasonable number of sources at international level that was relevant to the research. The literature review helped me to determine what had been written and what needed to be done.

1.12.2 Interviews

Of the initial 38 participants selected, a total of 25 individual interviews were conducted. The number was reduced because of a lack of availability of participants due to the Covid-19 pandemic. The participants were forensic analysts with more than 4 years' experience in ballistics. A semi-structured interview schedule was used to conduct interviews with participants (Annexure D). Welman and Kruger (2001:161) pointed out that, with a semi-structured interview schedule for participants, the researcher can use standard questions based on study aim and research questions. Open-ended questions were used so that the participants could respond comprehensively.

The following guidelines were followed for the conduct of the interviews as indicated by (Leedy & Ormrod, 2005:147-149):

- "Make sure the interviews are representative of the group": The researcher chose analysts with comprehensive experience and skills in the use of IBIS and investigation of firearms.

- “Find an appropriate location”: interview requests were sent by email to the participants, which were arranged to observe the restrictions of Covid-19 and to ensure that they felt comfortable in their own environment.
- “Get written permission”: permission to conduct research was obtained from the SAPS Research Division. Permission was also granted by each participant and all their details were kept confidential.
- “Do not place words in the mouths of individuals”: The researcher asked only research-related questions and recorded the exact responses of the participants rather than attempting to alter or interpret what the participants said.
- “Record answers verbatim”: on the interview schedules, the responses of the participants were written down.
- Confidentiality: the researcher only referred to the participants as ‘participants’ in this study for confidentiality purposes, since they stated that they would like to have their identity kept confidential.

1.12.3 Personal experience

According to Creswell (2014:83), researchers may use their experience but must decide how and in what way their understanding will be introduced into the study. The researcher was a police officer with 17 years’ service in the SAPS. In addition, the researcher had more than four years’ experience as a ballistics forensic analyst. Personal and practical experience helped the researcher to interpret the interview transcripts and data from the literature review.

1.13 DATA ANALYSIS

The researcher analysed all the data collected in order to obtain an overview of all the data. The researcher used Leedy and Ormrod’s (2005:151) “spiral data analysis” method to accurately capture all data and identify all common trends and patterns. Leedy and Ormrod (2005) submitted that, using a spiral approach to data analysis, allows data to be evaluated several times, as follows: organising the data; perusing the data several times in order to gain a sense of it as a whole; classifying the data by identifying general categories or themes, and synthesising the findings by integrating and summarising the data for the report.

Raw data obtained via the chosen methods of data collection was analysed (literature, interviews and personal experience). The data was first collected and then organised according

to the key theoretical concepts ‘IBIS, firearms identification, evidence’. Then information under each category was filed chronologically. In order to create a direct and comprehensive approach when analysing data, common themes were established (Welman & Kruger, 2001:202).

To distinguish differences and related meanings, information was compared within categories. Data collected was screened regularly and similar data and variations were classified together. These were easily recognised, accessed and then categorised where there was a need for information.

Themes were classified in a table which was organised as follows: the investigation of firearms-related crimes, awareness, operating and system usage with the views of each ballistics analyst as to whether they believed the system was accurate and successful.

1.14 METHODS TO ENSURE TRUSTWORTHINESS

1.14.1 Trustworthiness

As described by Streubert and Carpenter (2003:364) “trustworthiness” means “establishing the validity and reliability of qualitative research”. Rigour in qualitative research means accurately representing the participants’ experience. Qualitative research is reliable if it accurately reflects the experience of the study participants. Through the attention of the researcher to and confirmation of information discovery, “trustworthiness of data in method triangulation” is demonstrated. Pelto (2017:242) describes “triangulation” as using more than one form of study, as “an approach to assessing the validity and reliability of social and behavioural science data collection methods”. Credibility, reliability, transferability and conformability are the four criteria for measuring data trustworthiness.

1.14.2 Credibility

Kumar (2014:219) noted that credibility includes establishing that the participants in the study regard the findings as reliable or plausible. De Vos et al. (2011:419) clarified that “credibility is the alternative to internal validity” in quantitative studies. The goal is to prove that the study was carried out in such a way that the participants were correctly identified and represented. Credibility is shown when respondents accept the study results stated as their experiences (Streubert & Carpenter, 2003:38). Holloway (2005:8) notes that “the researcher must ensure that those participants are accurately identified and described in order to ensure credibility.”

The researcher asked all participants the questions included in the interview schedule in accordance with the study aim, research topic and by interviewing competent participants on the subject in order to ensure credibility. In addition, by gathering data from books, journals, the internet, interviews, and peer-reviewed publications containing data on the use of IBIS in the investigation of firearms-related crimes, the researcher ensured credibility and cited all sources.

1.14.3 Transferability

Kumar (2014:219) refers to transferability as the “degree to which qualitative study findings can be generalised or applied to other situations or conditions”, the ability to extend the results to other contexts or to other participants. The key focus of qualitative research is not generalisation or statistical means of generating the findings, but rather the definition of observations in the particular circumstances in which they take place. In a qualitative study, the responsibility for establishing transferability lies with those who wish to apply it in another setting.

Since qualitative research is carried out in a particular context, it is not easy to transfer the results to similar circumstances. Transferability in this study, however, was achieved through a dense explanation of background information and the way in which sampling technique was carried out, creating an audit trial which can be used by other researchers seeking to do similar research (Babbie, & Mouton, 2001:277).

1.14.4 Dependability

Dependability is similar to the concept of reliability in quantitative research (Kumar, 2014:219). De Vos et al. (2011:420) explain that the researcher should ensure that the research process is well documented and presented in a logical manner. Dependability is accomplished through securing the credibility of the results (Streubert & Carpenter, 2003:38). Holloway (2005:143) stated that “dependability is related to the consistency of the findings”. The analysis used the same testing tool to ensure consistency, namely an interview schedule to evaluate the techniques used to collect data, which was consistent. This suggests that if the research were replicated with the same participants in a similar setting, the results would be consistent. A reliable audit and a dense description of the research methods is another method to ensure dependability in this study, in which the researcher interviewed participants from the SAPS FSL who had a thorough knowledge of the topic.

1.14.5 Conformability

Conformability refers to the extent to which others may “confirm or corroborate the findings” (Kumar, 2014:219). Confirmability in qualitative research is also similar to reliability. It is only possible to compare findings if both researchers follow the process in a similar way (Kumar, 2014:219). If the study demonstrates credibility and fittings, it is also claimed that the study possesses confirmability (Streubert & Carpenter, 2003:38).

The researcher ensured that findings were the result of the data collected with the use of triangulation in promoting confirmability and to reduce the effect of researcher bias. The researcher asked all the participants the same questions as they appeared in the interview schedule during interviews to ensure confirmability. As a result, it is possible to prove that the results and interpretation of the results are not a figment of one’s imagination, but are specifically linked to the data (Liamputtong, 2013:26). The researcher maintained a record of all the literature consulted and participants’ interview transcripts to ensure confirmability.

1.15 ETHICAL CONSIDERATIONS

Ethics is concerned with an effort to formulate codes and rules of moral behaviour, according to Lacovino (2002:26). It is the process of ensuring that the study meets the ethical standards required (Kumar, 2014:282). As discussed by Leedy and Ormrod (2013:104-109), The researcher upheld the highest ethical standards, namely:

- Participants were protected from harm with no physical, psychological, social or emotional issues of any kind. During the study, no stress, humiliation or loss of self-esteem was caused.
- Participants were given the right to privacy and confidentiality: During the study, no person’s right to privacy or confidentiality was breached. The researcher kept the names and any means of identification of the participants strictly confidential. This will not be disclosed to others, unless a participant gives written permission.
- Study participation was entirely voluntary as participants were informed of the purpose of the study and the interview and what was involved prior to their participation. Prior to any participation, informed consent was obtained from each individual.
- The researcher received prior written consent from the SAPS Research Division to conduct research in the SAPS FSL ballistics section in Pretoria with respect to the research policy and to interview SAPS ballistics forensic analysts (Annexure A).

- Findings were reported completely and honestly without any distortion. There were no inflated, falsified or fabricated data or results.
- The researcher avoided plagiarism and did not interfere with anyone's intellectual property rights. Where data was scarce or inaccessible or some aspects required further research, it was clearly specified. All sources were referenced, and the work of other writers was cited and acknowledged by providing a complete reference list.
- The researcher adhered to UNISA's Research Ethics Policy (2013:9-10) and relevant institutional policies and guidelines. Personal data collected during the research will be kept a minimum of five years. The researcher am aware that the data obtained is proprietary and the research report is owned by the University of South Africa.

1.16 RESEARCH STRUCTURE

CHAPTER 1: GENERAL ORIENTATION

This chapter introduced the topic, explaining the research problem and discussing the background to the research. The aim of the research, aims, objective, questions, the value of the research with key theoretical concepts, the design and methodology of the research, data collection and analysis were reflected. Finally, methods used to ensure trustworthiness and ethical issues were discussed.

CHAPTER 2: WHAT IS THE MEANING OF INTEGRATED BALLISTIC IDENTIFICATION SYSTEM

The focus of this chapter is on an IBIS literature review to discuss the history, meaning and the functions of the integrated ballistics identification system.

CHAPTER 3: HOW IS INTEGRATED BALLISTICS IDENTIFICATION SYSTEM UTILISED DURING FIREARM INVESTIGATIONS?

This chapter deals with the historical background and the process of firearms investigation together with Firearms Control Act. This is followed by dealing with how the IBIS is used in the examination of firearms, the examination of fired cartridge cases and fired bullets.

CHAPTER 4: FINDINGS AND RECOMMENDATIONS

This chapter summarises and present the findings and makes recommendations.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW: THE MEANING OF INTEGRATED BALLISTICS IDENTIFICATION SYSTEM

2.1 INTRODUCTION

The emphasis of this chapter is a literature review on the integrated ballistics identification system to explore its purpose, history and comparison with other systems. Over the years, law enforcement has become increasingly complex, with technology evolving and a very rapid shift in the field of forensic science pushing the need for a better level of knowledge organisation within law enforcement agencies. This relates to the provision of forensic science services, technology and knowledge development and "the interpretation of analytical and other data as applied in forensic practice" (Heard, 2008:1). In 1997, the South African Police Service's FSL acquisition of the IBIS provided opportunities for careful analysis of firearm exhibits. The system is widely used and allows forensic experts link exhibits found at the scene of the crime to a specific firearm.

The researcher deals with significant concepts in this chapter to help the reader understand the concepts relating to the IBIS system. Only an introduction to the history, meaning and general overview of IBIS will be discussed.

2.2 HISTORICAL OVERVIEW OF INTEGRATED BALLISTICS IDENTIFICATION SYSTEM

Comparisons of bullet and cartridge case marks are usually carried out by firearms examiners, as established by King, Wells, Katz, Maguire and Frank (2013:5) who stated that, "from the 1930s to the early 1990s, firearms examiners used comparison microscopes that could compare two bullets or casings" at the same time. Although accurate, this was a slow and laborious process. Comparison microscopes would then make photographic snapshots of the images and be distributed, but generally, this was only done in isolated jusrisdictions. In the early 1990s, the ballistics imaging and the matching process was computerised. This led to digital cameras being used to take pictures of bullets and cartridge cases which were then scanned into a computer. These images were analysed by a software program and stored in a database. That increased the efficacy of the ballistics analysis process.

Moreover, FT (2009: np) suggested that all firearms examiners with access to the computerised system should be able to compare marks on a large number of bullets or cartridge cases

relatively quickly. When the computerised system was interconnected by means of a telecommunications system shared by a variety of law enforcement agencies, this enabled them to make a rapid comparison of bullets and cartridge cases used in crimes in one jurisdiction with those used in crimes in another jurisdiction (and thus the firearms from which they were fired). This contributed to solving many crimes, even seemingly unrelated ones, that would probably not have been solved otherwise. The use of computerised images of bullets and cartridge cases has thus simplified the preservation of a proper chain of custody of evidence, which is necessary if the bullets or casings are to be used as evidence in court cases (FT, 2019: np).

A computerised ballistics imaging system, named 'Drugfire' was developed in 1993 by the FBI. The system was developed by Mnemonics Systems Inc. Originally; Drugfire only allowed for comparison of marks on cartridge cases. Later, it was developed to compare marks on bullets as well. Some 171 law enforcement agencies participated in the Drugfire system (FT, 2009: np).

In addition, ATF founded "its computerised ballistics imaging system, developed by FT Inc.", in 1993, according to King, Wells, Katz, Maguire and Frank (2013:5). Originally called "Ceasefire," it is now called IBIS. Initially, IBIS only compared the marks on the bullets and was later extended to compare marks on cartridge cases. Some 103 law enforcement agencies started using the IBIS system. Of these, 70 IBIS system installations were financed by the ATF at a cost of approximately $19.3 million. Because the ATF and FBI systems have different ballistics records, some federal, state, and local law enforcement agencies use both systems. This is inefficient for system users and, because the two systems were duplicating information, in 1997, the ATF and the FBI agreed to move towards integrating the two systems (U.S Bureau of Alcohol, Tobacco, Firearms and Explosives, 2001: np).

According to Boesman and Krouse (2001), the National Integrated Ballistic Information Network (NIBIN) was set up in 1997 to unify Drugfire and IBIS. However, NIBIN operators soon realised that it was not technically possible to integrate the two systems, so efforts were directed at making the two systems "interoperable" which would allow users of one system to access the records of the other system. However, this also raised a number of technological difficulties. In 1996, ATF and the FBI entered into an agreement with the National Institute of Standards and Technology (NIST) of the Department of Commerce "to develop a standard for interoperability and to develop and monitor interoperability conformance tests". Although NIST made progress in its attempt to achieve interoperability between Drugfire and IBIS, the NIBIN administrators were responsible for the finalisation of the arrangements. Thereafter, the ATF and the FBI

agreed to establish a unified system using the ATF IBIS and the FBI's secure, high-speed telecommunications network. All significant data from Drugfire was re-engineered in IBIS format and NIST stopped its work (U.S. Bureau of Alcohol, Tobacco, Firearms & Explosives, 2001: np).

2.3 THE MEANING OF INTEGRATED BALLISTICS IDENTIFICATION SYSTEM

Braga and Pierce (2011:106) stated that the comparison of ballistics evidence was a labour-intensive and time-consuming task, as each piece of newly recovered evidence had to be manually compared to a vast inventory of recovered or tested bullets and cartridge casings. Roberge, Beauchamp and Evesque (2019:3) found that many automated ballistic identification systems (ABISs) had been developed to automate firearms identification with the emergence of digital imaging. There was, however, no way to automate the process, and given labour and time constraints, it was very difficult to match records across crime scenes (ATF, 2001: np).

The IBIS system was developed by FT Inc. during the early 1990s. This is a computerised system for the acquisition and storage of images of cartridge cases of unknown origin and those from known firearms (Thompson, 2011). When bullets are fired from firearms, they leave unique striation marks on both the bullet and the cartridge cases which could link a particular firearm to a specific crime. These striation marks are created by the passage of the bullet through the gun barrel. Impression marks are created by impact with the firing pin, breech face and ejector on a cartridge case. Both the striation and impression marks are unique to the firearm (Song, Chu, Vorburger, Thompson, Renegar, Zheng, Yen, Silver & Ols, 2011). Firearms examiners may link a firearm to a crime through the examination of these ballistics marks.

Drogin (2008:1) stated, however, that ballistics experts are more than toolmark specialists who "attempt to match tools like screwdrivers and crowbars to the marks they make when used on objects". He added that, although "firearm identification is often treated as a subspecialty of toolmark identification … "ballistics experts have wide-ranging expertise in many aspects of firearms; for example, they testify on topics ranging from whether a specific object is, legally, a firearm; to intricate reconstructions of crime scene evidence".

During interviews, participants were asked "What do you understand about IBIS?"

The participants' responses included the following:

- Eighteen participants responded, “IBIS is a system where digitally captured images of markings carried over during the firing process on cartridge cases and bullets are looked at to see if they were possibly fired from or in the same firearm.”
- One participant responded, “IBIS is computerised system used to determine a possible link between various reported cases.”
- Six participants responded, “Integrated ballistics identification system is a computerised system that links the crime regionally and nationally”, with one participant further stating that “The system links firearms-related crimes, and it plays a crucial role in the investigation of firearms-related crimes.”

All 25 participants responded from their own experience, as they referred to the IBIS as the system that scans, records, captures and /or acquire images of the exhibits and stores in the database.

Based on researcher’s own practical experience, the researcher can confirm that the IBIS system maintains a computerised database of images of bullets and cartridges of firearm crimes. Literature revealed that the purpose of IBIS was to help solve cold cases by comparing images of bullets or cartridge cases with those stored in the cold case knowledge databases, either from tests fired from confiscated firearms or exhibits retrieved from crime scenes. The output systems list the most appropriate matching candidates for a specific exhibit and continue to rely on the firearms examiner’s expertise to validate a possible match.

2.4 HOW THE INTEGRATED BALLISTICS IDENTIFICATION SYSTEM FUNCTIONS

According to Kirk (2015:3), the IBIS is an automated firearm identification system which consists of two different systems: the Data Acquisition Station (DAS) and the Systems Analysis Station (SAS). The DAS incorporates two of IBIS’s predecessors. The first is Bullettrax which is an acquisition platform for bullets. The second is Brasstrax which is an acquisition platform for cartridge cases. When cartridges are entered into the DAS, the first step is to label them using class characteristics such as calibre, make or firing pin type to allow for class characteristic filtration. The DAS then captures two-dimensional digital images of the breech face and firing pin. Once this is completed, the images are stored and used by the second system which is known as the SAS. Once a cartridge is entered into the SAS, it will automatically extract all of the characteristics that can be found in the image. These characteristics are then compared against every cartridge case in the database with matching class characteristics. An

independent search and match score are performed for both the breech face and the firing pin. These scores are referred to as the Breech Face Score and the Firing Pin Score. Two additional variables can be created by ranking all of the Firing Pin or Breech Face Scores between the entered cartridge and database cartridges (FT, 2009: np).

FT (2009: np) submitted that every firearm leaves unique identifying characteristics on the bullet and the cartridge during the firing process that can only be identified under a microscope. These marks are similar to fingerprints, unique to a specific firearm. For example, even two seemingly identical 9 mm pistols will not produce identical markings on the bullet and the casing. Therefore, the ballistics information can be used to determine which gun was used in a crime, and ideally to link it to the offender who used it. Research success depends on the quantity, quality and timeliness of ballistics information. This data will be of value to the police only if it is properly obtained, analysed and disseminated (FT, 2015: np). IBIS allows investigators to match bullets and cartridges that were fired from the same firearm (Morris, Law, Jefferys & Dearth, 2016:12).

The participants were asked “How does this system operate? What are its functions and how the functions are performed?”

All the participants understood this as follows: “The system captures digital images of the unique marks on the fired cartridge case and fired bullet.” One participant further indicated that “It records, compiles and compares various fired exhibits (bullets and cartridge cases) and can be used to identify correlations and/or similarities of all firearm tests fired and fired exhibits to each other.”

The researcher acknowledges from experience that IBIS is a national database that stores records and enables the user to compare exhibits obtained from crime scenes and samples fired from firearms submitted for review to determine if the firearm was used in one or more instances/crimes. When processing firearms-related data, law enforcement officers are faced with several challenges. Manual evidence processing methods require both time and resources, and often result in backlogs and missed investigative leads. There is a shortage of trained firearms examiners in some agencies, while others need to organise national programmes in several jurisdictions spread across broad geographic areas.

Furthermore, the participants indicated that “a digital signature is generated from the image and compared to all the other images in the database.” It is possible to create a list of possible

matches using a filter such as calibre and rifling, and an expert must view them to decide which images will make a match. The samples/tests are compared on a microscope to determine the result.

The IBIS system allows a large amount of information about exhibit and images to be exchanged and compared through the range of imaging sites, and facilitates the automated identification of potentially similar bullets or cartridge cases. High-resolution 3D imaging, advanced comparison algorithms, and a robust infrastructure are included in the new generation of IBIS technology. It is intended to meet the needs of law enforcement agencies who obtain data from firearms and components of their fired ammunition which can then be used in solving crimes (FT, 2019: np).

2.5 THE EMERGENCE OF 2D AND ADOPTION OF 3D IBIS SYSTEM TECHNOLOGY

According to FT (2019: np), early ballistic image collections used 2D technology, like the comparison microscope, for use in ABISs. The early versions of the ABISs relied on reflectance 2D imaging; this is highlighted by Braga and Pierce (2011:106) who stated that due to the "inherent specular nature of ballistic evidence, performance of the system was limited by the large image variability associated with relatively small differences on the object's surface". This limitation was overcome with the introduction of three-dimensional (3D) surface measurement using noncontact microscopy. Briefly, 3D imaging technology captures "three-dimensional data on ridges and valleys from the striations on the surface of a fired bullet to create a digital map of its surface topography that can be mathematically processed" (Braga & Pierce, 2011:107).

According to Braga and Pierce (2011:107), "recovered bullets are often mushroomed and fragmented" as they strike a target. The 2D technology was not very effective in detecting potentially identical markings among bullet images with those of less damaged and distorted cartridge casings recovered from crime scenes. Technological innovation has allowed for the precise imaging of 3D topography on bullets and cartridge cases. Furthermore, 3D information can help match bullet pairs that was not possible using 2D images or a comparison microscope. Furthermore, 3D imaging also provides investigator to compare bullets made of different materials (FT, 2019).

Previously unknown matches, which were later confirmed by a firearms analyst, are often found by law enforcement agencies in huge datasets of ballistic exhibits. Unlike a reflectance 2D image, which is highly dependent on the lighting geometry, the 3D topographic image of a

ballistic exhibit provides a true representation of its surface, which has enhanced the capacity of the system to provide reliable error rates or likelihood ratios with the comparison results. Higher resolution is achieved by laying the 2D texture over the 3D model with an adjustable simulated light source. This combination allows manipulation of the surface information by adjusting the overlays. This provides a panoramic digital image that closely resembles what firearms examiners can see under a comparison microscope (Toni & Brinck, 2008: np).

2.6 THE EFFECTIVENESS AND EFFICIENCY OF IBIS IN SOUTH AFRICA

After the introduction of the IBIS system to South Africa in 1997 by FT, SAPS has gone up to be ranked among the best in the world when it comes to ballistics investigations. This was revealed at the 10th anniversary of the IBIS at the SAPS Forensic Science Laboratories in Pretoria (Hosken, 2007: np).

The South African Police Service's FSL acquired IBIS to speed up the highly labour-intensive and time-consuming task of matching ballistics information in the examination of firearms. On average, the laboratory receives up to 30 firearms a day and a comparison takes up to three days to complete. Since the introduction of IBIS in 1997, 216 062 ballistics samples have been loaded onto the IBIS, the largest single ballistics database in the world. To date the system has assisted the Ballistics Section to link more than 29 205 cases nationally. Of these cases connected, 28 685 were cartridge cases and 520 were bullets. The system also assisted in connecting many cases such as gang-related cases, cash-in-transit cases, taxi violence cases and rhino poaching cases (Mkhabela, 2017).

All the participants were asked "How effective and efficient is the IBIS system?"

The participants' responses included the following:

- Twenty-three participants mentioned that, the IBIS system is effective and efficient, it saves time, and it eliminates non-matches and allows the examiners to focus on confirmation of matches. IBIS assists analysts to scan images on brass and Bullettrax and later view them on match point after correlation. The IBIS system automatically searches for similar images after scanning and synchronisation. Where there is a possible hit or similarities, then the specimens are verified under the microscope.
- One participant mentioned training as one of the requirements for an analyst to be fully certified to operate the IBIS system.

- One participant emphasised the importance of the quality of the images being captured/ acquired and that “depends on data processing and the final visual and manual screening by the IBIS analyst of which of the possibly are the most likely positives (meaning possibly fired from the same firearm). This has a number of different variables pertaining to its efficiency, but the system itself is very effective”.

From experience, the researcher is of the same view that the accuracy of the correlation depends on image quality which is also largely affected by lighting conditions of the system itself during the acquisition process.

IBIS is used to link ballistic evidence to previous investigations and to firearms that may have been used in the commission of multiple crimes, whether those investigations have been completed or are still ongoing. Such information can only be of value to the police if it is “properly collected, processed and disseminated” (FT, 2015: np).

The participants were asked: “Are there any practical problems experienced with the system?” The participants’ responses included the following:

- Twelve participants mentioned downtime of the system as the biggest problem experienced. The participants attributed the downtime mostly to contractual issues due to non-payment to the supplier. This created problems with processing cases as no cases were processed during this time with one participant further mentioning “if the bills are not paid, the system is shut down/offline”.
- Four participants highlighted technical issues with the system as one of the factors affecting efficiency at times.
- Three participants said just like any other electronic machine, the system might freeze, with one participant highlighting a different view, namely, that “practical problems come also from human error, when someone load erroneous information, like wrong calibre, make of the firearm and wrong particulars of the case.”
- One participant mentioned that problems occurred when exhibits were damaged and occurred often with fired bullets. It was difficult to place the image on the system and to find a match, with one participant mentioning that “practical problems such as system issues are there, but the technical support team is always on standby to resolve the issues. We have an ARS system where we report all system issues. The system was created by SITA and it’s

connected to the service provider who has a turnaround response of 24 hours to resolve system issues reported."

- One participant highlighted that the system tended to be slow because of the number of cases loaded on the system (volume).
- Four participants responded they were not aware of any practical problems.

From researcher's experience, the researcher is of the same view as participants that downtime due to contractual issues and technical problems are only some of many of the practical problems experienced with the system. These problems contribute greatly to the current backlogs experienced by the Ballistics Section which results in more delays in processing and finalising cases. Nevertheless, IBIS plays a very important role in the investigation of firearms crimes, it is effective and efficient, and it has solved and linked multiple cases and made it easier to eliminate non-matches.

2.7 SUMMARY

This chapter provided an overview of a very important role played by IBIS in providing support to various firearm crimes investigation. IBIS brought faster and more efficient acquisition, storage and comparison of digital images from bullets and/or cartridge cases for law enforcement agencies around the world. In this chapter, it was highlighted that the system is able to screen and link cases identified locally, nationally and even internationally that exist amongst firearms cases submitted for examination. With the use of computers and a modified microscope, operators can compare previously recorded images to new evidence.

Based on the participant's responses, it was evident that, since the inception of IBIS in South Africa by SAPS, the linkage rate has improved, and the system is the cornerstone of a successful firearms identification strategy because it is able to successfully link firearms-related evidence in a timely and comprehensive fashion. Because of its ability to store, share and compare a significant amount of information on exhibits and images across a network of imaging sites, and the ability to automatically identify and match bullets or cartridge cases, law enforcement agencies must capitalise on its technological potential. During its initial adoption, it was limited to cartridge cases that had already been examined by a firearms examiner and as a result, the programme languished. The vision did not match the potential. Rather than being used as a tool to link shootings that are already being examined, it is best used as a tool to

identify which firearm was used at which crime scene. The following chapter discusses the use of IBIS in the investigation of firearms.

CHAPTER 3

THE USE OF IBIS IN THE INVESTIGATION OF FIREARMS

3.1 INTRODUCTION

South Africa has been counted as one of the countries with the highest homicide rate globally, as cited by the United Nations Office on Drugs and Crime (UNODC) (2013:14) which further indicates that the rate in the country "is approximately five times higher than the global average". In 2013, two New York-based cardiologists, Bangalore and Messerli (2013:873-874), using information from the World Health Organisation and the Cambridge University Small Arms Survey, reported that South Africa had "the second highest rate of firearms-related deaths in the world", with approximately 9.41 deaths per 100 000 people. It was found that the U.S. had the highest rate of 10.20 deaths per 100 000 individuals, but it should be noted that the U.S. also has a higher ratio of weapons to 88.8 firearms per 100 individuals. When the Gun Control Act 60 of 2000 was promulgated, there was a decline in firearms-related crimes in South Africa. However, the SAPS Annual Report for 2017/2018 (SAPS, 2018) showed an increase in firearms-related crimes involving the repeated use of firearms.

In this chapter, the focus is on certain important concepts concerning the history of firearm identification, the Firearms Control Act, processes employed during investigations and the use of IBIS in the investigation of firearms.

3.2 HISTORICAL OVERVIEW OF FIREARM IDENTIFICATION

The science of firearm identification has developed over a period of time and is the result of certain events and the efforts of a number of individuals (Van der Westhuizen, 1996:286).Steele (2012:2) states that early firearms such as matchlocks and flintlocks were made one at a time by individual gunsmiths. Each barrel and each bullet mould was unique. The barrel length, width, and the size of the bullets reflected the idiosyncracies of its maker. The exact time when a man first discharged a rifled firearm, recovered the firearm bullet and noted that it showed upon its cylindrical surface a certain number of grooves, inclined in the same direction all of the same width, sloping at the same angle, and spaced equally about its circumstances, and that every other bullet fired through the same weapon showed similar markings, will never be known (Goddard, 1989). The fact that fired bullets acquired individual riffling marks from the barrels

they were fired through, was known to criminal investigators for some time prior to 1900 (Van der Westhuizen, 1996:286).

Firearms and bullets started to be mass manufactured in the early 19th century. The first type of handgun was “a small cannon of wrought iron or bronze, fitted to a frame or stock with metal bands or leather straps” (Heard, 2008:1). Manufacturers standardised the rifling; i.e., the grooves cut into a barrel to make a bullet more robust as it travels. A firearms expert like a manufacturer or police officer could look with the naked eye at a bullet from a crime scene and say whether it was too big to have come from a particular kind of firearm, or whether the bullet’s main rifling marks matched those on the barrel (Steele, 2012).

According to Rosenberg (2009: np), one of the first true tests of this new technology was in the aftermath of the Saint Valentine’s Day Massacre in 1929 which was carried out by gang members competing over bootlegging operations in Chicago. The Chicago police department brought the weapons used in the massacre back to Chicago for testing. Weinstein (2013: np) explained that Calvin Goddard, an experienced forensic scientist, was asked to compare the weapons to evidence found at the scene of the massacre using his new “ballistic-forensics” method. After test-firing the guns, Goddard proved that the weapons were used to kill the members of the North Side Gang, thereby absolving the Chicago police department of all blame (Weinstein, 2013: np).

However, Van der Westhuizen (1996:286) submitted that a reliable technique to demonstrate a match between two bullets was absent. Earlier cases showed that evidence mainly depended on the calibre, the shape of the bullet, presence or absence of riffling, and that the measurements of riffling on the bullet corresponded with the riffling in the weapon. Dack (2014:18-19) indicated that, in the early days, firearms identification lacked a scientific basis for assuming that all firearms leave uniquely identifiable marks. This changed with the invention of the comparison microscope. Before this, firearms experts had to remember the identifying marks on each specimen. The comparison microscope provided investigators with the ability to view two bullets or cartridge casings side by side which allowed for more accurate examination of the unique striae left on the bullet or cartridge case when the firearm was discharged. Since that time, these basic tools and techniques were used “to determine whether ammunition components were fired by a single firearm based on unique and reproducible microscopic and class characteristics, or to reach a ‘no conclusion’ result if insufficient marks are present” (Dack, 2014:18-19).

3.3 THE FIREARMS CONTROL ACT 60 OF 2000

According to the Government Gazette (2004) South Africa has a comprehensive firearms-control regulatory regime in place. It includes the Firearms Control Act 60 of 2000 (FCA) and its subsidiary legislation, the Firearms Control Regulations (FCA Regulations). Before these laws took effect in 2004, firearms were regulated through the Arms and Ammunition Act 75 of 1969. The regulatory authority is the National Commissioner of the SAPS, who is also the National Commissioner of Registrar of Firearms. The impact of the current regulatory framework on firearms-related crimes is difficult to determine. Although there was decrease in firearms-related crimes when the FCA came into force, recent SAPS crime statistics (2018) indicated an increase in firearms-related crimes in South Africa which involve a repeated use of firearms.

According to FCA 60 (2000: np), a firearm is defined as any device that can propel a bullet or projectile through a barrel or cylinder by means of burning propellant, at a muzzle energy exceeding 8 joules (6 ft-lbs); anything with the capacity to discharge rim-fire, centre-fire or pin-fire ammunition; any device that can be readily altered to be any of the above-listed firearms; any device designed to discharge any projectile of at least .22 calibre at a muzzle energy of more than 8 joules (6 ft-lbs), by means of compresseds; or any barrel, frame, or receiver of a device mentioned above.

However, the FCA excludes devices that would otherwise be considered firearms under this definition. For example, explosive-powered tools designed for industrial application for splitting rocks or concrete, or for application in the mining or steel industry for removing refractory materials, are not considered firearms. Stun bolts used in slaughterhouses, antique firearms, air guns, tranquilliser firearms, and paintball guns, flare guns, and deactivated firearms are also excluded. Furthermore, the FCA authorises the Minister of Safety and Security to exclude any other device.

3.4 FORENSIC BALLISTICS IDENTIFICATION OF FIREARM

3.4.1 The meaning of firearms identification

According to Whitley and Figarelli (2009: np), “the field of firearms identification, sometimes called ballistics, is at its heart the ability of a firearms examiner to determine if a particular bullet or cartridge case was fired from a specific firearm”. Karger (2008: np) defined forensic ballistics as “the application of ballistics for forensic purposes”. Giannelli (2007:548) stated that “firearms

identification is the forensic science discipline that identifies a bullet, cartridge case or other ammunition component as having been fired by a particular firearm to the exclusion of all other firearms". This is supported by Whitley and Figarelli (2009: np) who stated that firearm identification "refers to the study of firearms and includes the operation of firearms, cartridges, gunshot residue analysis, bullets and cartridge case comparisons". Furthermore, Whitley and Figarelli (2009: np) claimed that firearms transfer unique microscopic markings (created when the firearm was manufactured) to the ammunition components (such as cartridge cases and bullets). These can be used for identification purposes in investigations.

The firing pin, ejector, extractor, breech face and chamber marks create various types of marks on a cartridge case that can be used for examination. On bullets, lans and groove marks can be used for comparison purposes. When the ammunition component in question is discovered at the scene of a crime, it is retrieved and catalogued by the relevant authorities and submitted for analysis to the Ballistics Section. If a suspicious firearm is recovered, the firearm will also be submitted for examination. However, Steele (2012:1) submitted that ballistics, in the most basic sense, is the study of firearms and refers to the study of a bullet's path from the firearm, through the air, and into a target. In criminal investigations, however, ballistics is a term used for firearms identification: how recovered bullets and their cartridge cases are matched to the firearm from which they were fired.

During interviews, participants were asked "What is the required standard/level to become a qualified firearm examiner?"

The participants' responses included the following:

All 25 participants mentioned "training" from level 1 to level 12 as a requirement for a ballistics analyst to become a firearm examiner, and that the expert has to write and pass competency tests at all levels of ballistics case work.

Four participants out of the 25 further highlighted that "As set out in post requirements" that National Qualifications Framework (NQF) Level 6 is the minimum entry requirement for a ballistics expert; i.e., they "must have a relevant qualification either in science or law/criminology."

One participant mentioned that "After completion of training and competency tests, a certificate of specialist (i.e., a qualified firearm examiner) in firearm and toolmark examiners is awarded."

From the researcher's experience working as ballistics analyst, firearm identification refers to the ability of a firearms examiner to determine if a particular bullet and/or cartridge case was fired from a specific firearm. The examiner should be able to determine whether the small, often microscopic, markings on bullets or cartridge cases have been fired from a specific firearm. This requires extensive ballistics training in the theoretical and practical application of the forensic ballistic science (Dack, 2014).

Although the examiner cannot determine who fired a weapon, matching the ammunition to a weapon provides vital information to an investigator. Giannelli (2007:549) further indicated that "firearms identification does not directly involve ballistics". In fact, "a true ballistics expert may know very little about forensic firearms identification. Similarly, a firearms expert, a person knowledgeable about weapons and ammunition, may not be acquainted with this technique".

3.4.2 Standard operating procedure (SOP)

According to Civilian Secretariat for Police (2017:45), the level of professionalism within an institution can be benchmarked and measured. This, police leadership needs to establish the benchmark for professionalism within the SAPS.

The participants were also requested to answer the question: "Is there any standard operating procedure for firearm examination at ballistics?"

The answers to this question were as follows:

All twenty-five participants responded that "Yes, Standard Operating Procedure (SOP) have been established to ensure that all examiners use the same standard in firearm examinations." In addition, one participant stated that "the SOP for the firearm mechanism procedure, its objective is to provide a working procedure to ensure consistency and completeness of the firearm mechanism examinations." These procedures provide descriptive guidance on how to examine and record different types of firearms and their different mechanisms.

The Civilian Secretariat for Police emphasises the importance of the implementation SOPs and compliance with the guidelines. Supervisors and managers are encouraged to communicate SOPs to their employees and, if they are not met, to take administrative review measures (Civilian Secretariat for Police, 2015:26). Overseeing the plan will be the personnel in the Civilian Secretariat of the Police Service. (Civilian Secretariat for Police, 2015:45).

3.4.3 The important elements in firearm identification

According to Giannelli (2007:549), “an understanding of firearms identification requires some appreciation of firearms and ammunition”. Dack (2014:2) and Heard (2008:101) stated that the field of forensic science recognises four types of “ballistics”:

- Internal ballistics: “the forces, pressure, and ignition that operate on the bullet while still inside the firearm”;
- External ballistics: “the flight of a bullet between the firearm muzzle and its impact at target”;
- Terminal ballistics: “the mechanics of impact on both the projectile and the target”; and
- Forensic ballistics: “the analysis of bullet and cartridge case evidence and the use of that evidence to link specimens to each other and to particular weapons”.

According to Steele (2012:16): when a cartridge is fired, the firing pin strikes the primer. This impresses the firing pin’s mark into the soft metal of the primer. The primer contains a tiny bit of explosive, which, when hit, ignites the propellant. The propellant burns rapidly, producing gases that exert pressure in all directions on the head of the cartridge case, on the walls of the cartridge case, and on the bullet. The bullet is the only part able to move, and is forced out of the barrel, leaving the cartridge case behind.

Then the forensic expert examines the cartridge cases and bullets to the marks left when the bullet is fired to a particular weapon based on the assumption that a firearm leaves individually definable marks.

When the participants were asked: What is the most important element needed in firearm examination?

The participants’ responses included the following:

- Twenty-one participants indicated the need for training on “safety” and the use and handling of firearms, good observational skills, paying attention to detail “Firearm mechanism examination and classification”, during firearm examination.
- One participant also mentioned that as the examination/identification is performed manually to check specific features such as proofmarks, measurements and other related marking, the literature and internet is used for verification.

- One participant highlighted that one of the important elements is being “able to work independently, under pressure and remain neutral and unbiased in the conclusion of your findings.”
- One respondent answered, “I do not understand the question”, and another one responded, simply, “firearm”.

Considering the responses by the participants, it is clear, as noted by Dack (2014:3) that the technique of firearm identification involves the expert exercising caution. From my experience, safety is the most important element in the examination of a firearm, followed by the ability of the examiner to be able to use and handle firearms, good observational skills and paying attention to detail.

The examiner uses a comparison microscope or other magnification technology (IBIS) to view unique striae left on the projectile. The examiner looks for the marks created by the machined metal on the barrel, breach block, extractor, or firing pin on the projectile when the firearm is fired and can do any one or all of the following:

- identify the components, concluding that they came from the same source;
- eliminate the components, concluding that they did not come from the same source; or
- not reach a finding, meaning that there is not enough evidence to identify whether the components either did or did not come from the same source.

Using the terminology of firearm examiners, if there is enough agreement to make an identification, they often state that the likelihood that another firearm could have made the mark is a “practical impossibility” (Dack, 2014:3, Steele, 2012:17 & Heard, 2008:102).

3.4.4 Serial number restoration

According to Heard (2008:277), when a weapon is located, either as part of a crime or merely as a recovered item, examiners will try to determine where the weapon came from. The make and model can usually be determined from the weapon’s physical characteristics, such as shape and size, while its history, i.e., when and to whom the manufacturer originally shipped the weapon; and the chain of ownership, can only be obtained from the serial number.

Heard (2008:277) indicated that “all metals are polycrystalline in structure”, that is, “they are composed of irregularly shaped crystals or grains”. “When a number is stamped into metal, the

crystalline structure surrounding the stamped number is distorted and the grain structure is compressed. This effectively reduces the size of the grain or crystal size of the metal altering its physical and mechanical characteristics" (Mozayani & Noziglia, 2010:253).

As a result of this altered structure, the metal in the immediate area surrounding the stamped number, will change; e.g. in hardness, strength, magnetic, electrical and chemical properties. Even if the surface is filed or ground down until the number has just been removed, as is often the case where criminals try to prevent identification of the firearm, the altered surface will still reveal the original crystalline structure, if correctly treated by suitable etching reagent or a magnetic field is applied to the metal. This area of altered crystalline structure will conform to the outline of the number that has been filed off. Thus, it is almost impossible to completely remove all identification marks on a firearm.

3.4.5 Chemical restoration method

According to Mozayani and Noziglia (2010:253), the first step in restoring a serial number is to polish the surface where the serial number has been removed. A chemical reagent is applied to the polished area with a cotton wool swab. After about one minute, the reagent is rinsed off with acetone and viewed. The number will appear as a shadow which is often best viewed with oblique lighting. According to Heard (2008:280), the process can be accelerated by using an electrical current because the etching process is essentially an electrochemical process in which electrons are transferred as the metal is etched.

If nothing appears after one minute, the process is repeated for consecutive intervals of 2, 5 and 10 minutes for a total of 2 hours. The application of heat also appears to enhance the result (Heard, 2008:280). This is possible because stamping the numbers distorts the structure underneath the surface of the metal.

Chemical restoration is a type of chemical milling. Typically, chemical milling is used to remove material to create a desired shape. In serial number restoration, small amounts of metal are removed until variations in the metal corresponding to the serial number are visible. However, chemical restoration only works on a surface level and is successful only when the removal of the serial number has not gone too deep.

The examiner first sands the area where the serial number used to be. This removes any debris from the area left when the serial number was removed. The examiner then uses an acid to

slowly bring the number back to the surface. The type of chemical that is used depends on the material the weapon is made of. These acids can range from “Fry’s Reagent for a magnetic metal, which is a mixture of hydrochloric acid, cupric chloride, and distilled water, to an acidic ferric chloride solution for a non-magnetic, non-aluminium material”. Mozayani and Noziglia (2010:254) further highlighted that it is not always possible to restore a serial number if it has been too deeply ground away or drilled out because numbers are usually lightly stamped or engraved.

3.4.6 Magnetic particle restoration method

Mozayani and Noziglia (2010:253) stated that another form of serial number restoration is magnetic restoration based on variations in compressed vs. uncompressed steel’s magnetic properties. This is the same approach used to find flaws in steel artefacts by metallurgists and is known as magnafluxing. Magnetising the material and then spraying it with magnetic particle dust is a traditional procedure for the detection of minute defects or cracks in ferro-metallic objects. Any defects or cracks in the metal are indicated by magnetic particle accumulation. Again, this is due to a change in the metal’s crystalline structure around the crack or defect, resulting in an altered magnetic property (Heard, 2008:284). Magnetic particle dust is commercially available as a suspension in oil or water, or as a dry powder. The use of this procedure for the retrieval of erased numbers is a standard technique offers a great benefit in that it is non-destructive. It should, therefore, be used before trying other more harmful restoration techniques. The method will only work with ferro-magnetic metals as the material must become temporarily magnetised.

However, stainless steel, although non-magnetic, can also sometimes be treated with this method. It is believed that when stamped, the stainless-steel work hardens and becomes slightly magnetic. “This faint magnetic property in an area which is non-magnetic is often sufficient for a restoration” (Heard, 2008:285).

3.5 THE EXAMINATION OF FIRED CARTRIDGE CASES AND FIRED BULLETS

3.5.1 Fired cartridge cases

According to Thompson (2010:18), fired cartridge cases are often left at shooting scenes because the shooters seldom waste time searching for the ejected and fired cartridge cases which will contain both impressed and striated toolmarks from the firearm mechanism. Harris

and Lee (2019:171) defined toolmarks as impressions or striations or a combination of the two. Striated toolmarks are left in the surface of a softer medium by a harder tool moving across the surface which creates a pattern of scratches caused by slight defects in the face or edge of the tool that is in contact with the surface. On the other hand, impressions are formed by forcing the contact portion of the impression tool into the surface with little motion involved. A third category is produced by a combination of impressions and striations (Harris & Lee, 2019:171).

As with bullets, cartridge cases may also carry firearm class characteristics that can provide the examiner with the enough information to compile a list of potential manufacturers of firearms if the firearm itself is not available for comparison. Whenever a firing pin or striker impacts the cartridge primer, it leaves an imprinted toolmark “on the soft metal of the primer, and any microscopic imperfections on the surface of the firing pin can be transferred to the primer. In general, these toolmarks are individual and can be replicated during firings” (Van der Westhuizen, 1996:295).

Cartridge case identification involves comparing the cartridge case recovered at the crime scene and a test cartridge case obtained from the firearm after it has been fired. Cartridge cases are most often identified by breech face, firing pin impression, extractor, ejector, or chamber. Cartridge case identification is based on the same theory as bullet identification: “The whole principle of identification is based on the fact that since the breech face of every weapon must be individually distinct, the cartridge cases which it fires are imprinted with this individuality. The imprints on all cartridges fired from the same weapon are the same, and those on cartridges fired from different weapons must always be different” (Giannelli, 2007:558)

The comparison of cartridge cases may involve a “matching” of striae at the prism line of the microscope, or a side-by-side comparison as is usually done where straight impression marks are scattered all over the cartridge case (Van der Westhuizen, 1996:295).

3.5.2 Fired bullets

Thompson (2010:15) stated that fired bullets have impressed and striated toolmarks that are generated by the tool working on the surface of the rifled bore of the barrel. “Rifling is the construction of helical grooves in the bore that impart a rotary motion or spin to a fired bullet, thereby giving the bullet more range, stability, and accuracy”. Once a bullet and firearm are presented, they are tested to determine whether the suspected firearm fired the bullet. A

detailed comparison is made of the markings on the evidence bullet with the corresponding markings on the test bullets fired by the suspected firearm.

Van der Westhuizen (1996:295) suggested that by shooting the suspected firearm into a special water tank, test bullets are obtained. The tank usually has a recovery basket, or special tap with a recovery basket attached to it. By firing them into water tank leaves them undamaged, with no loss of fine markings. The instrument most generally suited to the examination of striated markings is the comparison microscope. For a bullet comparison, one usually examines “the fine striations on the interior of the land impressions on the bullet” (Harris & Lee, 2019:188).

According to Jackson and Jackson (2011:307), a bullet that has suffered little damage will reveal the calibre of its cartridge, as this is evident from the bullet’s shape and dimensions. In the case of a damaged but intact bullet, its weight will give an indication of its calibre and allow certain calibres to be excluded as possibilities. A knowledge of the calibre of the cartridge, coupled with an observation of the overall features of riffling marks present on the bullet, can enable a skilled firearm examiner to narrow down the types of firearm that could have fired the cartridge concerned.

When participants were asked the question, “How is this system used in the examination of firearms?” the responses were as follows:

- All firearms received, all cartridge cases and bullets from crime scenes, as well as all firearms handed in for destruction are recorded on IBIS database, a digital image of the unique marks on the fired cartridge cases and the fired bullets is captured by the system and stored in a data concentrator. A digital signature is created from the image and compared with all the other images in the database. After a list of possible matches is generated and viewed by experts, a comparison microscope test is performed.

The researcher acknowledges from experience that every crime exhibit is entered into the system; it correlates the exhibits and generates the possible candidates. The forensic analyst will view the exhibits to determine the likely candidates called hits. This automated method saves a lot of time for firearm examiners. It would be impossible to compare thousands of crimes exhibits manually, because it requires a lot of manpower, equipment, space and time.

3.6 CLASS AND INDIVIDUAL CHARACTERISTICS OF BULLETS

According to Giannelli (2007:551), the “class characteristics of a firearm result from design factors and are determined prior to manufacture”. Sometimes the general class characteristics can be useful in indicating the type of tool which made the mark (Harris & Lee, 2019:171).

Van der Westhuizen (1996:294) stated that when the bullet is fired in a rifled barrel, the riffling gives the bullet a number of markings called “class characteristics”. The make and model of the firearm from which the bullet was shot may be indicated by these markings. These characteristics are: the diameters of the “land and groove, the direction of rifling (left or right twist), the number of lands and grooves, the width of the lands and grooves, and the degree of twisting of the rifling” (Giannelli, 2007:551).

Giannelli (2007:551) further stated that: a .38 calibre bullet with six land and groove impressions and with a right twist could have been fired only from a firearm with those same characteristics. It could not have been fired from a .32 calibre firearm, or from a .38 calibre firearm with a different number of lands and grooves or a left twist. In sum, if the class characteristics do not match, the firearm could not have fired the bullet. Class characteristics play another role in criminal investigations. Frequently, the bullet is recovered before the firearm comes into the possession of the police. In this situation, the class characteristics provide significant information concerning the type of firearm that could have fired the bullet.

Whitley and Figarelli (2009:5) suggest that while basic characteristics which lead examiners to infer that “the bullet or cartridge was fired from a particular firearm class, other more specific markings may help identify the firearm make and model used. These individual characteristics may be marks created during manufacturing by random imperfections or irregularities caused by use, corrosion or damage”. Van der Westhuizen (1996:294) further argued that these “class characteristics, imperfections on the surfaces of the lands and grooves score the bullets, producing specific characteristics” which are unique to the specific firearm that fired the bullet This is confirmed by Giannelli (2007:553) that the recognition of a bullet as being fired from a specific firearm is based on the characteristics of the individual barrel. No two barrels can create the same markings on a bullet, even those made consecutively using the same tools. They are as individual and unique as fingerprints. Thus, although the class characteristics of the bullets fired by two different firearms of the same type may be similar, the individual characteristics may differ. The critical concern, however, is whether this uniqueness enables the examiner to reach

an accurate conclusion from the microscopic striations imprinted on the surface of bullet. The probability that another firearm would have identical bore imperfections is such that examiners can generally conclude that a bullet has been fired from only one specific firearm. In effect, this opinion is based on probability theory.

3.7 INTEGRATED BALLISTICS IDENTIFICATION SYSTEM ACQUISITION PROCESS

3.7.1 THE BRASSTRAX

3.7.1.1 Fired Cartridge case acquisition

The Brasstrax acquisition station (Figure 1) allows cartridge case data to be entered into an IBIS network, according to FT (2019:2). Brasstrax is a computerised system used to obtain and store cartridge images of cases that can be used in investigations (FT, 2015:1).

Figure 1: Brasstrax Fired Cartridge Case Acquisition Station

Source: *FT (2019)*

Brasstrax captures both high-resolution 2D images and 3D topographic information on things like the breech face, the fire-pin prints on the primer, (Figure 2), the ejector mark for the centre fire cartridge cases (Figure 3) and the full head of the projectile (Figure 4).

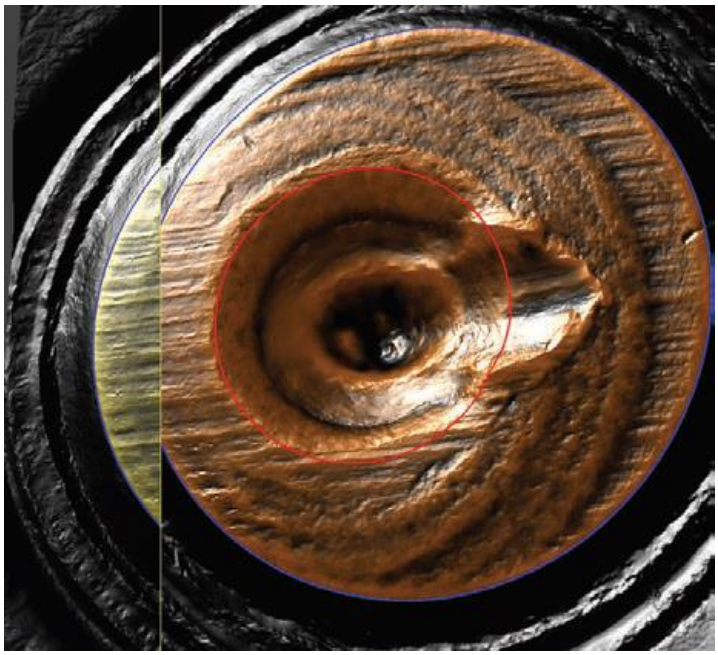

Figure 2: 3D Primer

Source: FT, (2019)

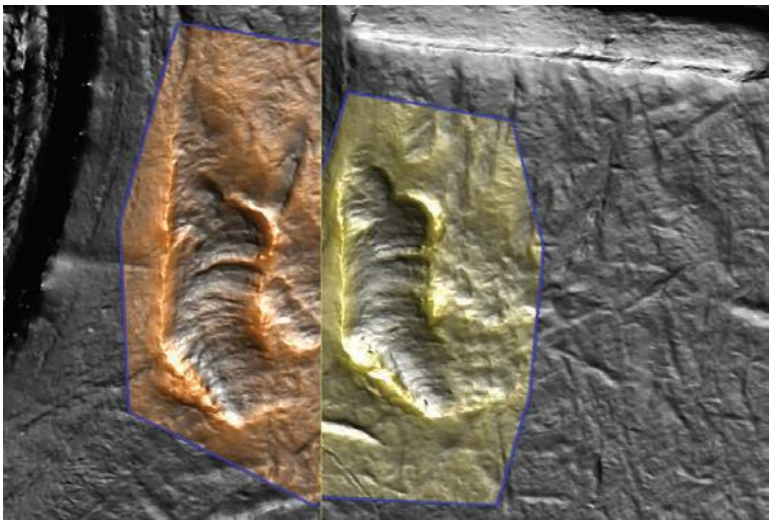

Figure 3: 3D Ejector Mark

Source: FT, (2019)

Figure 4: Fired cartridge cases

Source: FT, (2019)

These images are stored in databases and sophisticated algorithms are used to match the images against each other. Filters such as calibre, rifling specifications, date of crime and date of entry produce lists of potential associations and correlations ranked in terms of their significance. If there is a definite correlation, the physical evidence items are compared by a forensic analyst on a comparison microscope to reach a final decision (FT, 2019:2).

The Centre for Forensic Science (2018: np) noted that automation minimises variability in the decisions that are made by different examiners. Image focus, image lighting, and area of interest description automation ensures consistent image quality for visualisation and consistency for optimal comparisons.

The features of Brasstrax are:

- Detection of automated flow back and washout.
- Automated self-test and modification.
- Hands-off activity enables multitasking.
- Several levels of magnification.
- Full range of calibres: .17 to .50 and for shot shells from .410 bore to 10-gauge.
- Detailed help and user guides online.

- Multiple sources of light, including a patented ring light.

According to Morris, Law, Jefferys and Dearth (2016:16) for acquisition of a sample on the IBIS system, a case file is created which can contain several exhibits. Information such as the investigator, case number, type of offence, and other, is contained within this case file. This data contained is not easily accessible by the examiner from IBIS. In order to relate the data to a particular set of scores, the data must be encoded into the case file identifier (laboratory number).

3.7.2 THE BULLETTRAX

3.7.2.1 Acquisition of Fired Bullet

For the bullet acquisition component, Bullettrax is used (Figures 5 and 6).

Figure 5: Bullettrax Fired Bullet Acquisition Station

Source:FT, (2019)

Figure 6: Bullettrax

Source: FT, (2019)

The station digitally captures the surface of a bullet in 2D and 3D (Figure 7) providing the Bullettrax acquisition station with a topographic model of the marks around its circumference, which is allowing for the information to be entered into an IBIS system. It also provides the details of the microscopic surface and bullets' macroscopic shape. Bullettrax uses sophisticated surface-tracking technology to automatically adapt to damaged and fragmented bullet deformations, as cited by (FT, 2019:3).

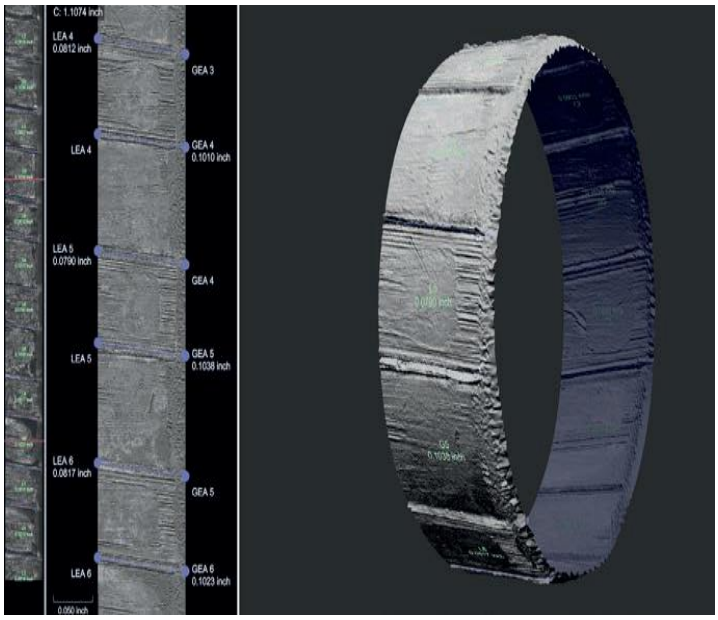

Figure 7: Wraparound Bullet Acquisition

Source: FT

The process of acquiring the images has been fully automated, this is done so that less operator training is required and produces consistent image quality and optimal correlation performance. Bullettrax features include:

- Detailed 2D images and accurate 3D images at the sub-millimetre level.
- Single-shot video acquisition in a full image.
- The acquisition of damaged and fragmented bullet regions.
- Intelligent control of projectile surface damage and fragmentation.
- Rapid acquisition.
- Consolidated focusing and lighting of images for IBIS networks.
- Automatic image segmentation.
- Simple bullet-mounted accessories.
- Easy-to-operate using intuitive software.
- Conventional, polygonal, and unrifled rifling.
- Wide variety of firearm calibres, from .17 to .50

3.8 THE MATCHPOINT

Matchpoint is used as an analysis station for reviewing potential matches from IBIS algorithms. High-resolution 2D images and 3D topography provide remarkable viewing capabilities and can be used for analysis of cartridge markings (Figure 9). A myriad of uses and functions help to identify similar candidates. High-level review of the effects of correlation and visual comparisons allows non-matches to be eliminated easily. Powerful visualisation tools enable one to recognise matches that nonetheless surpass conventional comparisons. Indeed, matchpoint increases identification success rates despite being less labour-intensive.

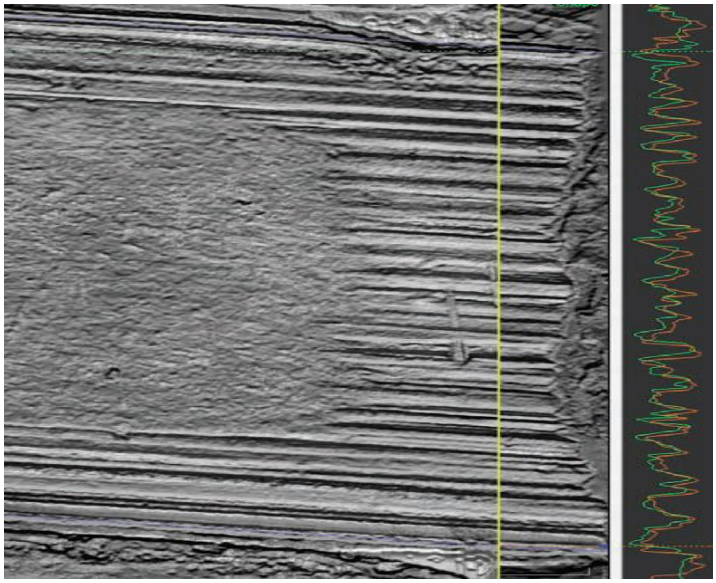

Figure 8: Side-by-Side

Source: FT, (2019)

Bullets that are acquired using “Bullettrax” are considered to be individually focused, continuously wrapped images. Bullettrax can create full life-sized images in 2D, 3D or even a combination of both. This simplifies the comparison of damaged bullets, which allows for easier and more refined comparison of microstructure. The combination of enhanced patterns and the realistic bullet shape reduce hunter efforts to locate and identify bullet markings on bearing surfaces. Cartridge cases are viewed based on a variety of regions of interest including 2D, 3D and a mix of both. As a result, certain regions will be needed to find a match. 3D information is useful in comparing firearm cartridge cases.

Figure 9: Matchpoint

Source: FT, (2019)

Features for Matchpoint include:

- Independent correlation scores for each captured image type.
- Access to 2D and 3D photos on-site and remotely.
- Ability to display and compare all exhibits in the IBIS database manually.
- Ability to display outcomes and photographs in the style of a tile panel.
- Ability in a side-by-side mode to compare exhibits.
- Dynamic tools for visualisation, including the ability to display 2D and 3D images, adjust magnification, and monitor light intensity and direction.
- Ability to display cross-sectional 3D bullet picture profiles.
- Ability to assess and display successive matching striations (CMS).
- Ability to handle future matches and positive identifications and to connect them.
- Ability to capture and export images from the screen.
- Tests the surface topology of a bullet to the level of the nanometer quantitatively.
- Provides 360-degree circumference imagery of the lands and grooves of a projectile and partial areas imagery.

- Ability to produce regular reports and custom reports.

3.9 DATA CONCENTRATOR

According to FT (2019:4), for the exhibits obtained using Brasstrax and Bullettrax acquisition stations, the data concentrator offers scalable storage and backup facilities. Usually, for each exhibit obtained from its acquisition stations, the data concentrator produces a correlation request automatically for comparison with previously captured exhibits. In order to refine searches based on crime trends and geography, the spectrum of similarities is designed to cover specific acquisition sites on an IBIS network.

For subsequent evaluation using a match point analysis station, the correlation server processes the correlation queries, and returns the results to the data concentrator. Data concentrators can be centralised or distributed, depending on the scale of the IBIS network, and can accommodate local and remote communication for acquisition stations and analysis stations. Remote configurations depend on the availability of sufficient bandwidth to ensure that the analysis stations operate efficiently. To preserve the value of historical data as an IBIS network evolves, the data concentrator has been designed to host migrated data from IBIS Heritage systems that have been decommissioned. This allows the mixed data sets obtained on IBIS Heritage, IBIS TRAX-3D, and IBIS TRAX-HD3D systems to be thoroughly analysed (FT, 2019:4).

3.10 CORRELATION ENGINE

3.10.1 Comparison Processing and Data Sharing

The IBIS Correlation Engine uses complex algorithms for FT (2009: np) to compare exhibit image signatures with all other relevant exhibits in a particular IBIS network. Resultant correlation scores rank potential matches according to similarity. To correspond to known crime patterns, the scope of correlations can be optimised. Multiple levels of correlation offer collaborative capabilities between police departments around the country.

3.11 SUMMARY

The forensic process of examining the characteristics of firearms and cartridges or bullets left behind at a crime scene involve forensic examination. In this field, forensic analysts are responsible for examining and connecting bullets and cartridges to firearms and firearms to

offenders. In an attempt to find the registered owner of the firearm, serial numbers that have been tampered with can be raised and recorded. To do this, nitric acid is the most common reagent used to raise obliterated numbers.

This chapter focused on the second research question of this research. Various techniques and equipment including IBIS technological equipment used by FSL ballistic section were described with the objective of highlighting the functions and the role they play. The research showed that FSL ballistics section has the ability and the necessary equipment that can be used to successfully link exhibit to a firearm and assist in combating and investigation of firearms-related crimes. However, the FSL ballistics section has not used IBIS fully due to inefficient processes and challenges faced by the section. Furthermore, the section cannot handle the current backlog of cases which impacts negatively on turnaround time to finalise cases and issue final reports.

CHAPTER 4

FINDINGS AND RECOMMENDATIONS

4.1 INTRODUCTION

South African Police Service mandate as stated by the constitution of the republic, Section 205 of 1996 is to prevent, uphold and investigate crime. With its FSL, the Ballistics Section is facing significant challenges with caseloads and inefficient processes that hinder analysis and finalisation of cases.

The aim of this research was to evaluate the current processes employed during firearm identification. In order to address the problem, the researcher identified two primary questions that guided this study. These questions were:

- What is the meaning of IBIS?
- How is IBIS utilized during firearm investigations?

To address and achieve the aim of the study, which was to evaluate the current processes employed during firearm identification, the researcher obtained data through interviews, a literature review and my personal experience. The findings and recommendations are provided. The findings relate to the research problem, research aim and the research questions.

4.2 FINDINGS

The following findings were made on the basis of literature and interview data.

4.2.1 PRIMARY FINDINGS

4.2.1.1 Research question 1: What is the meaning of integrated ballistic identification system?

- During the research, it was established that IBIS was developed in the early 1990s by FT Inc. and is a system used for acquisition and storing of images of cartridge cases of unknown origin and those fired from known firearms.
- All 25 participants were familiar with what IBIS entails. Participants responded clearly from their own practical experience, as they referred to IBIS as the computerised system that scans, records, captures and/or acquires images of the database's exhibits and stores. All the participants showed an understanding of the concept.

4.2.1.2 Research question 2: How is integrated ballistic identification system utilised during firearm investigations?

Information obtained through interviews and literature review revealed several factors relating to the use of IBIS, particularly firearm investigation.

- It was established that the identification (investigation) of firearms is the ability of a firearms examiner to determine whether a specific bullet or cartridge case has been fired from a particular firearm.
- It was found that IBIS is a computerised system used to acquire exhibits during firearm examination.
- Literature revealed that, before IBIS was developed, a camera was used to take pictures of exhibits.
- It was also revealed that after a firearm is received for examination by the examiner, cartridge cases and bullets from crime scenes, as well as firearms handed in for destruction (in terms of a firearm amnesty), these exhibits are captured onto IBIS database.
- It was established the system is used to capture digital images of the unique marks on the fired cartridge cases and fired bullets and store them in a data concentrator.
- It was found that forensic analyst will view the exhibits to determine the likely candidates called ‘hits’.
- It was established that the system (Bullettrax) is very slow and time-consuming.

4.2.2 SECONDARY FINDINGS

The results below address the secondary findings to the research questions.

4.2.2.1 Research question 1: What is the meaning of integrated ballistic identification system?

During the study, the following information was established:

4.2.2.1.1 IBIS technologies

It was found that IBIS consist of Brasstrax with features:

- Detection of automated flow back and washout.
- Automated self-test and modification.
- Hands-off activity enables multitasking.

- Several levels of magnification.
- Full range of calibres: .17 to .50 and for shot shells from .410 bore to 10-gauge.
- Detailed help and user guides online.
- Multiple sources of light, including a patented ring light,

and Bullettrax had the following features:

- Detailed 2D images and accurate 3D images at the sub-millimetre level.
- Single-shot video acquisition in a full image.
- The acquisition of damaged and fragmented bullet regions.
- Intelligent control of projectile surface damage and fragmentation.
- Rapid acquisition.
- Consolidated focusing and lighting of images for IBIS networks.
- Automatic image segmentation.
- Simple bullet-mounted accessories.
- Easy-to-operate using intuitive software.
- Conventional, polygonal, and unrifled rifling.
- Wide variety of firearm calibres, from .17 to .50

4.2.2.1.2 Fired cartridge case identification

Cartridge cases are most often identified by:

- Breech face,
- Firing pin impression,
- Extractor,
- Ejector and
- Chamber.

4.2.2.1.3 Class and individual characteristics of bullets

It was found that these characteristics are:

- Land and groove diameters,
- The direction of rifling (left or right twist),
- The number of lands and grooves,

- The width of the lands and grooves,
- And the degree of the rifling twists.

4.2.2.2 Research question two: How is integrated ballistic identification system utilised during firearm investigations?

It was also established that SAPS faced challenges in day-to-day use of the IBIS system. These challenges as raised by participants can be broadly presented as follows:

- Operational demands like backlogs;
- Physical resources; and
- Financial resources.

Furthermore, the study has revealed that the IBIS system is not sufficiently used to expedite linkage and finalisation of cases and issuing of expert findings.

4.3 CONCLUSIONS

This research aimed to provide an accurate and valid representation of the factors relevant to the research question, i.e. to explore how IBIS is used in the investigation of firearms crimes. Therefore, the purpose of this research was to evaluate the current processes employed during the investigation of firearms.

The findings apply to other FSL regions in Durban, Port Elizabeth and Cape Town, although the study focused primarily on FSL Pretoria.

Conditions that make it necessary to use IBIS technology to a greater extent are the rise of firearms-related crimes involving the repeated use of a number of firearms. The adoption of IBIS technology by the FSL division of the SAPS was associated with the objective of speeding up the highly labour-intensive and time-consuming task of matching ballistic evidence during firearms investigations. South Africa has professionalised laboratories for forensic science with advanced technology for ballistic imaging. The study revealed that inefficient systems and processes that cause backlogs at FSL Pretoria, downtime that can last for days or weeks due to technical problems and/or mostly contractual (non-payment) problems with the service provider, an inefficient and very slow system (Bullettrax) in acquiring bullets and time delays in identifying ballistics hits have impeded the effective use of IBIS. As a result, the effectiveness of a proven forensic technology in the SAPS lab was diminished.

4.4 RECOMMENDATIONS

The findings of this research obtained through interviews are the basis of the recommendations in this study; the researcher's literature and personal experience and the following recommendations are made:

For SAPS and FSL ballistics section to optimally use IBIS in the investigation of firearm crimes, it is recommended that proper training, operational planning, and adequate physical and financial resources be implemented.

4.4.1 Training

A high degree of expertise is required to analyse ballistics evidence as technology continues to evolve and becomes increasingly complex. Education is required to improve ballistics analysts' awareness and skills in the use of the IBIS system and ensure the admissibility of such evidence in court.

It is recommended that guidelines be compiled for ballistics analysts along with a suitable training programme. The programme should prioritise continuous development for the use of IBIS and all ballistic analysts should attend annual refresher workshops detailing the rationale for the use of IBIS and what IBIS means. This will develop skills and then deliver better outcomes that will ensure a better conviction rate in South Africa's courts of law. This will also be beneficial, not just for the SAPS, but also for South Africa's general population. This will allow ballistics analysts to be aware of any new technologies and system developments.

4.4.2 Adequate physical and financial resources

It is recommended that the SAPS and the FSL ballistics section do away with outsourcing the IBIS system, in order to maintain control over how the tasks are being performed, monitored and because of contractual conflicts, this would help prevent unnecessary system downtime, thereby allowing maximum use of the system in order to reduce backlogs.

It is also recommended that permanent in-house IBIS technicians be appointed which will reduce the system maintenance burden and operating costs. Unlike management, the use of permanent IBIS technicians would be more cost-effective. Therefore, technical problems would be resolved quickly, there would be fewer delays in processing cases, and production work would continue.

It is recommended that SAPS should ensure that forensic analysts are emotionally and mentally supported, financially well looked after, as the field of forensic ballistics is a science and requires a scarce skill from the examiner. This will improve performance.

More manpower is needed with ample resources that are readily available for them to perform their duties to their best ability, which would reduce the existing backlog, while improving the turnaround time to complete cases and issue reports.

4.5 RECOMMENDATIONS FOR FUTURE RESEARCH

More research on newly developed systems similar to an IBIS, which is faster, more advanced and compatible with the needs of the FSL ballistic section, is recommended.

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ANNEXURE A: PERMISSION LETTER FROM THE SAPS

South African Police Service | Suid-Afrikaanse Polisiediens

Privaatsak Private Bag X9.	Pretoria 0001	Faks No Fax No.	(012) 339 3518

Your reference/U verwysing:

My reference/My verwysing: 3/34/2

THE HEAD: RESEARCH
SOUTH AFRICAN POLICE SERVICE
PRETORIA
0001

Enquiries/Navrae: Lt Col Joubert
AC Thenga
Tel: (012) 393 3118
Email: Joubertg@saps.gov.za

APPROVED

Mr AM Dlangamandla
UNIVERSITY OF SOUTH AFRICA

RE: PERMISSION TO CONDUCT RESEARCH IN SAPS: EVALUATING THE UTILISATION OF INTEGRATED BALLISTIC IDENTIFICATION SYSTEM (IBIS) IN THE INVESTIGATION OF FIREARM RELATED CRIMES IN PRETORIA: UNIVERSITY OF SOUTH AFRICA: MASTERS DEGREE: RESEARCHER: AM DLANGAMANDLA

The above subject matter refers.

You are hereby granted approval for your research study on the above mentioned topic in terms of National Instruction 1 of 2006.

Further arrangements regarding the research study may be made with the following office:

The Divisional Commissioner: Forensic Services:

- **Contact Person:** Col NM Rababalela
- **Contact Details:** (012) 421 0440/082 378 3457
- **Email Address :** RababalelaM@saps.gov.za

Kindly adhere to paragraph 6 of our attached letter signed on the **2020-09-07** with the same above reference number.

MAJOR GENERAL
THE HEAD: RESEARCH
DR PR VUMA

DATE: 2020 - 10 - 14

1

ANNEXURE B: ETHICAL APPROVAL

UNISA university of south africa

UNISA 2020 ETHICS REVIEW COMMITTEE

Date: 2020:06:01

ERC Reference No. : ST46
Name : AM Dlangamandla

Dear Ashison Mluleki Dlangamandla

Decision: Ethics Approval from 2020:06:01 to 2023:06:01

Researcher: Mr Ashison Mluleki Dlangamandla

Supervisor: Mr John Mokoena

Evaluating the utilisation of integrated ballistic identification system (IBIS)in the investigation of firearm related crimes in Pretoria

Qualification: MA Criminal justice

Thank you for the application for research ethics clearance by the Unisa 2020 Ethics Review Committee for the above mentioned research. Ethics approval is granted for 3 years.

The low risk application was reviewed by the CLAW Ethics Review Committee on 1 June 2020 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.

The proposed research may now commence with the provisions that:

1. **The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.**
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

ANNEXURE C: INFORMED CONSENT LETTER

Ethics clearance reference number: ST46

Title: Evaluating the utilisation of integrated ballistic identification system (ibis)in the investigation of firearm-related crimes in Pretoria.

I, Mluleki Dlangamandla, an MA (Criminal justice) student at the University of South Africa, I am currently conducting research with Mr. R J. Mokwena, a Lecturer, in the College of Law. We are inviting you to participate in a study entitled: EVALUATING THE UTILISATION OF INTEGRATED BALLISTIC IDENTIFICATION SYSTEM (IBIS)IN THE INVESTIGATION OF FIREARMS-RELATED CRIMES IN PRETORIA.

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to evaluate the utilisation integrated ballistics identification system (IBIS) during the examination of firearms.

WHY AM I BEING INVITED TO PARTICIPATE?

The non-probability sampling which requires judgement and not randomisation has been used; hence participants were selected for the main reason for ease access. The researcher has purposefully selected the members of FSL Pretoria, in Gauteng, South Africa to participate in this study because they hold the information required for the study.

You were chosen to participate in the study because you have knowledge about the firearm examination process. All the information you will provide will be treated as confidential and nowhere in the study will your name be mentioned, and all the information provided by you will solely be used for the purpose of this research study.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY? The study involves interviews and the participants are expected to answer the questions asked as honestly as possible. The participants will be expected to answer in-depth questions and the duration for the interviews will be between 30- 60 minutes.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

A statement that participation is voluntary and that there is no penalty or loss of benefit for non-participation. Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The participants won't benefit any money or there won't be any financial gain. But the participants will benefit because the information they have provided will assist the police in their operations, methods, and strategies.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There won't be any negative consequences for the participants who will participate in the study.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research or your name will not be recorded anywhere and no one will be able to connect you to the answers you give. Your answers will be given a number, or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in the office of the researcher for future research or academic purposes; electronic information will be stored on a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No payment or any incentives for participating in this study will be provided by the researcher to participants.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Research Ethics Review Committee of the Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

The researcher has already approached SAPS for permission. Permission is still pending approval. Once received, the researcher will be able to approach the section commander to elaborate more with the documentation at hand (permission letter, ethics clearance, and informed consent) and request the availability of members, including him or herself.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

The participants will be able to receive a copy of the study once it is completed and approved by the university and met all the standards, and a summary of the report has been presented to the organisation.

For further information concerning the research, please contact Mluleki Dlangamandla at 072 518 1906 or email address: mluluam@gmail.com, the findings are accessible for 2021.

Should you have concerns about the way in which the research has been conducted, you may contact 082 479 6498, email: mokwerj@unisa.ac.za

Thank you for taking the time to read this information sheet and for participating in this study.

Thank you.

CONSENT TO PARTICIPATE IN THIS STUDY

I……. (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits, and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications, and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname…… (Please print)

Participant signature……...Date……

Researcher's Name & Surname: Mluleki Dlangamandla

Researcher's Signature: 

Date : 23-11-2020

ANNEXURE D: INTERVIEW SCHEDULE

MEMBERS OF THE SOUTH AFRICAN POLICE SERVICE FORENSIC SCIENCE LABORATORY THAT ARE/WERE INVOLVED IN THE INVESTIGATION OF FIREARMS

SECTION A. BIOGRAPHICAL DATA FOR ALL PARTICIPANTS

Please state your full names.

How old are you?

What is your home language?

Are you stationed at FSL Ballistics Section as a forensic analyst?

Currently, what rank do you occupy?

How many years of service working at ballistics?

What is your highest qualification?

SECTION B. SEMI-STRUCTURED QUESTIONS FOR ALL BALLISTICS ANALYSTS

1. Have you ever been involved in firearm examination?
2. Do you have any relevant training with regard to firearm examination?
3. At what level are you currently trained?
4. What is the required standard/level to become a qualified firearm examiner?
5. How many cases have you examined?
6. In your opinion, what is the most important element needed in firearm examination?
7. Is there any standard operating procedure for firearm examination at ballistics?
8. What systems does your section employ during firearm identification? Is it manual or automated?
9. What do you understand about integrated ballistic identification system (IBIS)?

10. How does this system operate (what are its function(s) and how are the function(s) carried out)?

11. How is this system utilised in the examination of firearms?

12. How effective and efficient is the system?

13. Are there any practical problems experienced with the system?

14. Would you recommend any improvements to the system?

15. Are you required to compile a report of your findings?

ANNEXURE E: TURNITIN REPORT

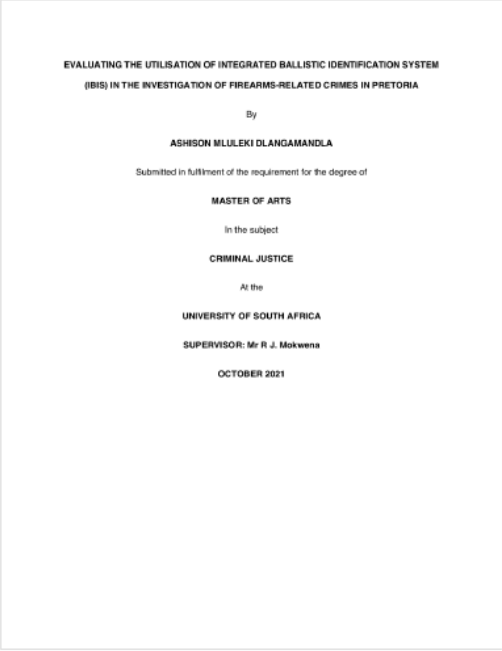
turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Ashison Mluleki DLANGAMANDLA
Assignment title:	Complete dissertation/thesis for examination
Submission title:	EVALUATING THE UTILISATION OF INTEGRATED BALLISTIC ID...
File name:	Mluleki_Dlangamandla_Dissertation_2021.docx
File size:	3.52M
Page count:	81
Word count:	20,634
Character count:	117,536
Submission date:	12-Oct-2021 04:04PM (UTC+0200)
Submission ID:	1671969256



EVALUATING THE UTILISATION OF INTEGRATED BALLISTIC IDENTIFICATION SYSTEM (IBIS) IN THE INVESTIGATION OF FIREARMS-RELATED CRIMES IN PRETORIA

By

ASHISON MLULEKI DLANGAMANDLA

Submitted in fulfilment of the requirement for the degree of

MASTER OF ARTS

In the subject

CRIMINAL JUSTICE

At the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: Mr R J. Mokwena

OCTOBER 2021

ANNEXURE F: DECLARATION OF PROFESSIONAL EDITING

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26 March 2021

Declaration of professional edit

EVALUATING THE UTILISATION OF INTEGRATED BALLISTIC IDENTIFICATION SYSTEM (IBIS) IN THE INVESTIGATION OF FIREARMS-RELATED CRIMES IN PRETORIA

By

ASHISON MLULEKI DLANGAMANDLA

I declare that I have edited and proofread this thesis. My involvement was restricted to language usage and spelling, completeness and consistency and referencing style. I did no structural re-writing of the content.

I am qualified to have done such editing, being in possession of a Bachelor's degree with a major in English, having taught English to matriculation, and having a Certificate in Copy Editing from the University of Cape Town. I have edited more than 200 Masters and Doctoral theses, as well as articles, books and reports.

As the copy editor, I am not responsible for detecting, or removing, passages in the document that closely resemble other texts and could thus be viewed as plagiarism. I am not accountable for any changes made to this document by the author or any other party subsequent to the date of this declaration.

Sincerely,

UNISA: D. Ed. Education Management
University of Cape Town: Certificate in Copy Editing
University of Cape Town: Certificate in Corporate Coaching

Professional EDITORS Guild

Jacqui Baumgardt
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Membership number: BAU001
Membership year: March 2021 to February 2022

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