RFID TAGS FOR THE EXPEDITION OF BODY PART PROCESSING IN
LARGE SCALE DISASTER VICTIM IDENTIFICATION INCIDENTS

A COST AND FEASIBILITY PILOT STUDY

By

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DECLARATION

I declare that this manuscript does not contain any material submitted previously for the award of any other degree or diploma at any university or other tertiary institution. Furthermore, to the best of my knowledge, it does not contain any material previously published or written by another individual, except where due references has been made in the text. Finally, I declare that all reported experimentations performed in this research were carried out by myself, except that any contribution by others, with whom I have worked is explicitly acknowledged.

Signed: Tiana De Almeida

Dated: 27th November 2018
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Part One

LITERATURE REVIEW

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Abstract

In 2001, over 2,000 lives were lost at the World Trade Center. Approximately 280,000 deceased victims were a result of the Asian tsunami of 2004, and 168 fatalities after the Oklahoma bombing in 1995. Whether the disaster incident is large or small, the legal responsibility falls on forensic investigators to positively identify every victim, for the purpose of returning the remains to their respective families. In forensic science and more specifically, disaster victim identification (DVI), an unforeseen incident can result in the demise of a mass of lives. Identifying the fallen victims is of vital importance. Highly skilled specialists and investigators are involved in the DVI processes in order to expedite the processing of body parts. However, a research gap remains in regard to the timeliness of human remain examinations at large scale DVI incidents. The expedition of DVI investigations is crucial as it impacts the number of positive identifications that are made, whilst issues such as decomposition may challenge forensic investigators. Radio Frequency Identification (RFID) technology is an advanced system that transmits a radio signal, in order to track and identify objects. This review aims to demonstrate how RFID technology has the ability to significantly decrease forensic examination and identification time of victims, through sub-dermal implantation of microchips into human remains. Although the cost of implementing RFID is a limitation, the technology has proven to be successful in several organisations on an international scale and has been effective through sub-dermal implantation in humans as well as animals. Through utilising RFID, forensic investigators and legal authorities will be equipped to conduct an expeditious DVI process and hence, determine a greater amount of positive deceased victim identifications.
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Figure 1. The RFID Trovan tag, encapsulated in a glass vial that is approximately 1cm in length

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<tr>
<td>AM</td>
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<td>DNA</td>
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<td>DVI</td>
<td>Disaster Victim Identification</td>
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<td>Global Positioning System</td>
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1. Introduction

In the field of forensic science and disaster victim identification (DVI), a disaster is defined as an unforeseen incident that consequently results in the demise of a mass of lives. Such incidents may include, however are not limited to, natural disasters, traffic or technical accidents and terrorist attacks. Following these fatal events, DVI processes are conducted by forensic investigators in order to identify the fallen victims, as this is the highest priority. Qualified and experienced specialists, such as pathologists, odontologists, anthropologists, fingerprint experts, photographers, and many more, are involved in order to expedite the processing of body parts. This legal responsibility falls on the investigators to positively identify every victim, to the best of their ability, for the purpose of returning the remains to their respective families.

The sequence of processes that are conducted by investigators involve four phases which are acknowledged and executed globally at the aftermath of any disaster incident. After several large scale DVI incidents that have occurred internationally, the four-phase process has demonstrated to be a reliable procedure, where post-mortem evidence of human remains were positively identified to match the data of missing individuals. The DVI INTERPOL recognises that technology is continuously developing and as such, has enabled the operations and procedures to become increasingly effective. It is also mentioned that such technologies cannot be a substitute for the experts and skills that are involved in each phase. However, this project aims to aid the expert forensic officers by employing technology that could potentially be utilised at DVI incidents, in a way that will expedite the process of identification.
In order for the DVI process to be conducted successfully and expeditiously, the four phases must be strictly adhered to. The first phase involves the processing of the human remains and property at the scene of the disaster. The post-mortem is phase two, where a detailed analysis of the remains is conducted in a mortuary. Next, being the third phase, the ante-mortem process is conducted. This includes collecting the data of missing individuals from numerous sources. Reconciliation is the fourth and final phase, where data from the post-mortem and ante-mortem is matched, for a potential positive identification\(^1\).

At the aftermath of a disaster, victims are found to be the citizens of various countries. For this reason, the responsibility of the DVI procedure of phases falls on the officials and experts of those respective countries. This responsibility is known to be the “Good DVI Governance”, that includes the sensibility, sensitivity and moral treatment of each victim. The officials of the country where the incident occurred, also have the highest duty of conducting such DVI procedures, that should consequently result in the positive identification of as many victims as possible\(^1\).

The approach to responding to a horrific event can be made, to a greater extent manageable, by classifying the disaster as an open or closed form. The DVI INTERPOL states that in the event of a major and unfortunate disaster, where several deceased victims are unidentified, and no previous records or data are obtainable, it would be classified as an open form disaster\(^1\). The difficulty with such cases is that there is no starting point to begin a missing person list, hence becoming complicated to gain information on the total number of deceased victims. Consequently, specialists must conduct an efficient and meticulous investigation for the purpose of successful DVI procedures\(^1\).

A closed disaster, on the other hand, is defined as a disaster where each individual is identified. An example of this, listed by INTERPOL, is an aeroplane crash with an
extensive list of passengers that were onboard\(^1\). Hence, this list can be accessed immediately, and more positive identifications of individuals can be made by employing DVI procedures sooner. There may also be disasters that could be classified as both open and closed, in which case, officials must be broad-minded. In any case, classifying the disaster can significantly reduce the amount of time that is spent on DVI procedures by managing the scene appropriately\(^1\).

After the examination of deceased victims from a disaster, authorities must then confirm the identities. The post-mortem information or results, are significantly impacted by factors such as the amount of time that the human remains were exposed and vulnerable to environmental conditions as well as how damaged or decomposed the remains are. It is of vital importance that the analysis procedures of identification are conducted in a reliable and scientifically accurate manner. They should also be methods that can be undertaken in a field environment, whilst in a feasible amount of time. The DVI INTERPOL states that the primary methods of identification include fingerprint analysis, DNA analysis and odontology, as they are highly dependable\(^1\). Secondary methods of identification can include, however, are not limited to, descriptions of the individual, medical records, scarring or tattoo designs, and wearables on the remains. This method is not adequate, however supports the primary identification method. All information that is obtained through AM and PM examinations should be recorded accordingly for the purpose of evaluation, and comparison to information that might also be obtained from a victims residence. The quality of such recordings is of the utmost importance in any investigation\(^1\).

The DVI INTERPOL Guide recognises that the general impression of an identification process is that it is time-consuming. The purpose of this research is to outline the
difficulties that forensic authorities encounter when conducting such investigations. Unfortunately, due to the general misconception of standard international procedures, families of those who have lost their lives in disaster incidents tend to become disgruntled at the extensive time that is taken. As such, this research aims to provide and investigate a potential solution for the timeliness response to mass disasters. The result of an accelerated forensic investigation could to a great extent, relieve the stress and anguish of surviving family members and prevent decomposition\textsuperscript{1}.

By conducting several mass disaster investigations, international authorities have developed a numbering system that has been clearly outlined in Annexure 13 of the DVI INTERPOL Guide\textsuperscript{1}. At the scene of a disaster incident, the remains of a victim should be assigned a distinctive number, where it is required to stay, as it would be associated to the victim and any personal belongings. This identifying number is used on all forms of documentation and relevant exhibits or samples for the duration of the mass disaster identification process. Additionally, labels and several forms must be completed by officials as the investigation is underway. Annexure 11 of the INTERPOL Guide provides two specific forms and they are known to be the Post-Mortem (pink colored) Victim Identification: Unidentified Human Remains form, and the Ante-Mortem (yellow colored) Victim Identification: Missing Person form\textsuperscript{1}.

Instructions of the detail and how to fill each form is outlined, along with directions on how to fasten DVI labels to an exhibit. It has also been mentioned that with the evolving of technology, bar codes have been utilised for the purpose of tracking body bags. The remains of a deceased victim, along with their belongings and affiliated documentation, are placed in a body bag that includes the PM identification number in the bar code\textsuperscript{1}. The instructions for labelling and completing the relevant forms for identification, are to some
extent complex and would vary in the case of unique situations. Furthermore, filling the documents would be a tedious process for forensic officers at the scene, considering that each document has a minimum of eighteen pages. For these reasons, the research project that will be conducted, aims to simplify the process of identification through the use of RFID technology.

Radio Frequency Identification (RFID) is an advanced technology that transmits a wireless radio signal, in order to track and identify objects. This technology has been implemented and invested in businesses on a global scale. Biohacking with the use of this device has also emerged for the purpose of biometric animal identification. A study has indicated that the RFID system has been commercially applied and has been beneficial in several ways, however it may raise privacy issues, which would not affect the field of forensics and DVI. The technology has been implemented in manufacturing processes, inventory control, transportation, logistics, security, and recalls. The system itself is known for its reliability as well as its consistency in performing at a high standard. It enables information to be stored in transceivers, and the data to be read automatically. As such, the device can be read at any place or at any time.

Chudy-Laskowska has indicated that an RFID tag may contain information that details the object, the goods in transport, as well as its location. There are several advantages to the utilisation of this technology, and this includes its wireless capabilities, with a distance range as far as several tens of meters from the reader, its automatic operating system, and it is scarcely visible, unlike general barcodes. Passive designs containing a chip may feature a replaceable/non-replaceable power source, where the power is provided to the chip and expands the area of operation. Active tags contain a power source, that enables the identifier to measure physical characteristics such as
temperature, light, pressure, the rate of movement and disfiguration. All of these results can be stored in the memory of the device\textsuperscript{1}.

The technology has a far greater amount of benefits when compared to the drawbacks. RFID possesses “read and write” operations and packaging will not create a barrier for the operation. As such, by implanting the tag sub-dermally, the device should be capable of receiving the information of the victim or remains. The rate of transmission is high, information can be updated regularly, the data will be encrypted and can be used in several programs\textsuperscript{3}. Dirt/weather resistant tags are capable of operating in a vast temperature range, with a high reliability and tracking location system. There is a chance of reading several tags at one time, and the technology examines the conditions/environment where the object was located. The cost of the advanced technology however, is a disadvantage. With the transmission of radio frequencies, there is a health risk for those involved or consistently operating the system\textsuperscript{3}. Through making use of the RFID system, unemployment rates may increase. Passive tags must be read at a slower rate in order to ensure the encryption of data, whilst other tags may experience reading issues due to a short distance\textsuperscript{3}. Although, many of these limitations may be avoided through careful consideration in the field of forensics and DVI.

In the context of large scale DVI incidents, the use of an RFID tagging system has the potential to significantly decrease the valuable forensic examination and identification time of victims. Amongst various other evidence types, DNA profiling is known to be an accurate and systematic procedure that can positively identify body parts of a victim. However, obtaining and collecting a high-quality DNA sample can more often than not, be relatively complex due to the aftermath of a DVI incident. The preservation of cadavers is made difficult by environmental conditions as well as the risk of cross contamination\textsuperscript{6}. 
Bode Technology is known to be a “forensic DNA services and products provider” that has successfully utilised the RFID system for the tracking of evidence and case files to improve “efficiency, accuracy and security” of forensic examinations and the chain of custody procedures. With the potential use of the RFID system, microchips could be implanted in the remains or belongings at the disaster scene by investigators, details can be input, the remains could be packaged and dispatched sooner for further analysis. The technology is also likely to provide comprehensive information that will assist with the chain of custody. Hence, the use of RFID tags could substantially expedite the processing of human remains in large scale DVI incidents.

2. Discussion

2.1 Mass Disasters

2.1.1 DVI Processes

The DVI INTERPOL Guide, initially published in 1984, has been reviewed and amended by experts and authorities, as experience was gained from disaster incidents that have occurred over many years. Some international disasters where experts have gained valuable experience, that has contributed to the making of the INTERPOL Guide include: the Oklahoma bombing in 1995, where there were 168 fatalities; the World Trade Center in 2001, as many as 2,000 lives were lost; the Asian tsunami that occurred in 2004 had approximately 280,000 deceased victims; and hurricane Katrina that took an estimated 2,000 lives. The DVI Guide’s sole purpose is to provide a reference, explanations and instructions to INTERPOL Member Countries, in the case of a disaster incident where identifications of victims should be made. It is intended for use by experts in the field of forensics as well as law, by local and national “strategic managers and planners and
operational practitioners” to aid in organizing DVI teams and managing the procedures that should be conducted at an incident¹.

There are a number of highly skilled and experienced specialists who are involved in the DVI investigation process, some of which include forensic pathologists, forensic odontologists, fingerprint experts, forensic biologists, forensic anthropologists, photographers, scene and PM recorders, evidence collection and management teams, investigators, and missing persons officers. The four phases of the DVI process, as mentioned previously, are conducted by these experts, as they ensure that all procedures are accurate and efficiently performed. The DVI Guide details the first phase as the scene, where the area would be treated as though it was a crime scene, where all remains, exhibits and property are kept in their original locations. Crime Scene Examiners and DVI Specialist Teams, would then be required to forensically examine the scene, according to standard procedures¹.

In accordance with the DVI Guide, all human remains must be identified with the precise location recorded. Each remain must be marked with a numbered post or evidence plate along with adequate documentation that must be completed. A recovery number should then be attached to the remains and is used as a reference throughout the process. A body bag is used to store the human remains and the reference number is then placed on the outside of the bag¹. To simplify this process, RFID microchips could be utilised to tag the remains, then all relevant information, such as the location, by GPS tracking, would be stored in the chip itself. This removes any uncertainty that information may go astray in the DVI process.

As the scene management plan is completed, the forensic examinations of photographing, recording, and exhibit collection can commence and be completed. At this
point, information can be noted on to the PM (pink colored) Victim Identification: Unidentified Human Remains form. The PM form is a nineteen-page document that provides a checklist regarding specific details of the deceased victim. Other operations such as “recovery, storage and transportation of human remains and property” should be interrelated with this process. The preservation and storage of evidence exhibits must also be involved. As this lengthy process may become tedious for specialists to conduct, it is possible for RFID technology to address this issue by reducing the time it takes to document all necessary details regarding the disaster victims.

For the purpose of conducting the second phase, Post-Mortem, a (temporary set-up or pre-established mortuary should be utilised, for the examination and storage of the human remains. At this stage, photography, fingerprint analysis, DNA sampling, odontology, autopsy and radiology procedures are carried out. Any wearables or other belongings to the remains are analysed, cleaned and stored appropriately. Further information that has been observed during this phase is also recorded on the pink PM form. As this phase comes to its completion, the remains are placed in secure storage until a formal identification has been made and is approved by authorities or the Coroner.

The AM, where information is gathered regarding missing individuals in order to positively identify when compared to a deceased victims data, is the third phase of the DVI process at the event of a large scale disaster. A missing person list is generated from families and friends who express concerns of a loved one and are then interviewed to collect adequate details of the potentially deceased victim. Belongings, wearables, medical/dental records, photographs, DNA and fingerprints, are amongst the highest priority of details, samples and descriptions that are collected for comparison. These details are recorded on the eighteen-page, AM, yellow colored Victim Identification:
Missing Person form. After this form is sufficiently completed, the file is examined and compared against the PM information, and if the requirements for a positive identification are met, the file is passed on to the Reconciliation Centre. Again, it is possible to minimize the time spent on completing large paper documents, by utilising and taking advantage of a secure and reliable system such as the RFID technology.

The fourth and final phase of the DVI process occurs at the Reconciliation Centre, where the PM and AM documents are compared for the purpose of positively identifying disaster victim remains. Following this, and provided that all necessary thresholds have been met, the individual cases are prepared and presented to an identification board of authorities, in order to come to a final conclusion. The results that are evidence to the final conclusion, a report that indicates comparisons, along with a “certificate of identification”, are all presented to an authority such as the Coroner, for each human remain. A death certificate is formally issued, that confirms the identity and cause of the victims death, as the conclusions are accepted by authorities. Finally, as the process comes to a conclusion, preparations can begin for the victims remains to be returned to their respective loved ones.

Section 7.16 of the DVI INTERPOL Guide considers how information is recorded and managed. It stresses the importance of the data that is subsequently collected from a disaster and will be used for the entirety of the investigation into the identification of victims. Several considerations have been mentioned that should take precedence in the process and these include: “identifying and recording what documentation has or is being made and in what form” (electronic or handwritten), “identifying how scenes and objects will be recorded (e.g. photographic, video maps or sketches) and how such recordings will be managed”, as well as “determining how all recordings will be stored and transferred.
confidentially and in a timely way". The DVI Guide indicates that the confidentiality of information should also be placed a high priority in such investigations.

With the use of the RFID system, the technology may be able to minimize or even eliminate the need to make decisions, such as determining if electronically inputting or hand-writing information will be suitable for further processing. The reader/writer device may have the capability to store essential details that relate to a particular exhibit, furthermore reducing examination time. This would allow for a greater number of victims remains to be forensically examined, and therefore an increase in positive identifications. Through implementing this system, investigation officers can be assured that the information remains confidential, as it has the potential to track the location and provide details of the chain of custody.

As mentioned previously, Annexure 13 of the DVI INTERPOL Guide explains the numbering system that should be followed in a DVI operation. The purpose of the numbering system is to simply identify the remains of deceased victims or separate parts of a body and distinguish it from other items of evidence. The guide suggests that DVI labels should be made of “moisture proof material." Alternatively, it could be protected by a transparent plastic covering. The label itself should be “securely fastened to the disaster victims remains." This may present a complication, as there is a high risk of the label becoming detached, damaged and misplaced. To resolve this issue, glass-encased RFID tags could be directly implanted into the cadaver/body parts, therefore lessening the possibility of misplacement or confusion between human remains. It may also provide investigating officers with assurance that the process can be conducted successfully, and with ease.
2.1.2 Managing the timeliness of identifying disaster victims

Three case studies by Sondorp et al. were conducted after the 2004 South Asian tsunami disaster that affected the countries of Thailand, Indonesia and Sri Lanka. The authors intended to document how the fatalities of a mass of victims were managed after the large scale disaster incident. Body recovery, storage of remains, timeliness, identification processes, and associated health risks that may have occurred, were amongst the stages of the DVI procedures that were considered and examined as part of the study. The published article, written in 2006, states that guidelines “for managing mass fatalities following large natural disasters” were not provided. The DVI INTERPOL Guide, published in 2013, currently includes descriptive instructions on the process of managing a multitude of casualties. Both documents however, discuss the necessity of a reliable and manageable DVI procedure. Sondorp et al. mentions that the “psychological well-being” of survivors may be negatively impacted as a result of mishandled or unidentified victims. The INTERPOL similarly states that victim identification is their highest priority, as it is a “legal obligation and moral necessity”. For the purpose of forensically identifying bodies expeditiously, and for the families and friends of victims, RFID tags could be implemented. Therefore, it is highly likely that more victims may be positively identified.

2.1.3 The decomposition of human remains

The post-mortem process of rapid decomposition is the consequence of several conditions, which include: humidity or weather conditions; the surface that the body is in contact with, e.g. soil properties, as well as types of water (salt or freshwater) that the remains are located in; insect or scavenger activity; clothing; burial and depth; trauma to the body; and the weight of the body. Autolysis and putrefaction are a part of the decomposition process however, the rate of decaying may vary due to the condition of
the human remains themselves\textsuperscript{11}. Tumer et al. discovered that the properties and textures of soil can significantly affect the decomposition of human remains and this should be considered in the estimation of postmortem intervals in crime scene investigations\textsuperscript{10}. Magni et al. conducted research that considered the “fate of floating remains in any aquatic environment” \textsuperscript{11}. The results of the study concluded that marine life activity on the cadaver assisted in estimating the post mortem interval\textsuperscript{11}.

Sondorp et al. indicated that the decaying of human remains made the process of visual victim identification difficult after a period of time\textsuperscript{9}. At the scene of the disaster incident, freezers were unavailable for the storage of human remains, and consequently, dry ice was utilised. Alternatively, the method of temporary burial was conducted due to a lack of forensic capacity. Following the tsunami disaster, forensic management plans were not thoroughly established, hence the rate of decomposition increased, the timeliness of the response was restricted, and fewer victims were positively identified\textsuperscript{9}. For this reason, the implementation of RFID technology could significantly increase the response time of forensic experts, which in turn would prevent further decomposition of human remains.

\textbf{2.1.4 The storage of human remains}

In order to prevent further decaying of cadavers or body parts, the DVI INTERPOL Guide indicates that mortuaries should be utilised for storage. Other cooling facilities such as forensic medical institutes, local cemeteries/crematoriums, temporary mortuary suppliers, ice skating rinks, refrigeration facilities, underground garages and refrigerated transport containers, may also be used in the event of a large scale DVI incident\textsuperscript{1}. The remains should be stored at a temperature of 4-6°C for examination, unless it would be stored for a lengthy period of time, it is kept at -14°C. It is required that a list of remains is attached to the outside of the facility, and a duplicate should be updated in a central
registry. This ensures accuracy and reliability of the DVI process\(^1\). To aid the process of storing deceased victims, the RFID system would be capable of retaining and updating information. This would remove the complexities in maintaining inventory.

### 2.1.5 The challenges faced at DVI incidents

At the scene of a mass disaster, it is possible for health and well-being issues to arise and these risks relate directly to the work that DVI officials perform. Physical hazards such as altitude sickness or working in extreme weather conditions (extreme heat or cold exposure) should be considered and managed appropriately\(^1\). Black et al. recognises that by handling several dead bodies, there is a high chance that DVI members of staff could become infected with diseases\(^1\). There are three specific infectious hazards that are likely to be encountered, which include: blood-borne viruses (Hepatitis B, Hepatitis C, and HIV); gastrointestinal (Salmonellosis, E coli, and Cholera); and respiratory infections (Tuberculosis)\(^1\). The DVI INTERPOL Guide recommends that all personnel are protected against such hazards and direct contact with human remains, by using full Personal Protection Equipment (PPE)\(^1\). Cross-contamination can be avoided if DVI officers follow the set guidelines and requirements\(^1,\,13\). With the implementation of the RFID system, cross-contamination can be further eliminated, as implanters are utilised to insert the glass-encased microchips into the human remains. This will decrease the amount of physical handling of exhibits by forensic investigators, thereby reducing the risk of health hazards.

An article by Winskog et al.\(^21\), considers other challenges that may arise at the scene of a disaster. This can include the DVI process that is conducted in “under-resourced and sometimes isolated locations”\(^21\). From this, another concern is raised as there may be many individuals with “different nationalities, languages and experience”\(^21\). To aid officers in this instance, the RFID system could simplify procedures, by allowing only specific
details, such as identification numbers and/or GPS locations, to be input and stored in the memory of the device. Communication between investigators may then be less complex.

2.1.6 The importance of chain of custody

Sutton et al. expresses the importance of maintaining chain of custody by describing the integrity and continuity of each item of evidence. It is crucial that each exhibit does not become contaminated, as there is a risk of a decrease in evidential value. The authors describe ‘integrity’ as demonstrating that an item of evidence has been correctly managed and has not been interfered with, in regard to the removal, addition or alteration of case material. They define ‘continuity’ as the point in time where an item of interest becomes potential evidence, and its location and/or movements are documented, until a final conclusion is reached by authorities. These terms are used in crime scene investigations as well as DVI incidents by forensic officers. The standard procedures for chain of custody, include recording observations or details in documents, registers and/or logbooks. Each officer or individual that handles the exhibits, must also conform with the chain of custody procedures, therefore successfully maintaining integrity, continuity and evidential value. In order to increase the efficiency of this process, RFID writer devices may be used to store all of such information on a microchip that is implanted in the evidence. The system would recognise GPS location and hence, the evidence can be monitored, and the chain of custody is maintained. By implementing this method, written documents can be removed from the process, thereby reducing the time that is consumed by inventory control.

2.2 RFID Technology

Radio Frequency Identification (RFID) technology, is an advanced system that has great potential to be a successful replacement for the barcoding system. It has the ability
to store large amounts of data, adapt to different functions or activities, and is an operation that can be modified with ease. The chipless system is unique due to its features of identification as well as its “tracing and tracking capabilities” 3, 15. Karmakar et al. confirms that RFID uses sensor technology the purpose of “real-time monitoring of assets” 15. For this reason, RFID is well suited for use in the forensic field of DVI incidents.

As mentioned previously, RFID technology transmits a wireless radio signal, for the main purpose of identifying and locating items 3. It allows for database management, the control of inventory, logistics, security of data storage, and possesses read or write functions 3, 15, 17. Karmakar et al. states that some RFID tags can show details regarding the environment that surrounds the object 15. This can include “temperature, pressure, moisture content, acceleration, and location” 3, 15, all of which factors are necessary and may assist officers in the DVI process. There are three known classifications of RFID tags, that include active, semi-active and passive. Each type of tag is structured differently due to its “on-board power supplies” 15. Active tags contain a power source (battery), which further develops signals and provides energy to the chip 15, 16. The example that has been provided by Want 16, describes an active tag, a transponder that is fastened to an aircraft, in order to determine its country of origin. According to Karmakar 15, a semi-active tag also possesses a battery, however it only provides energy to the chip. Unlike the active and semi-active tags, the passive tag does not contain a source of power, as it searches for energy from a signal that is emitted by an RFID reader device 15. This is ideal for a DVI process as the chip life remains forever 15. Another reason why RFID passive tags should be utilised is due to its structure, as it has a form of encapsulation 16 (see Figure 1 below). Chudy-Laskowska and Want state that the encapsulation protects the chip and the tag
antenna from the surrounding environmental conditions, which is suitable for DVI operations\textsuperscript{3,16}.

Figure 1\textsuperscript{16}: The RFID Trovan tag, encapsulated in a glass vial that is approximately 1cm in length.

2.2.1 RFID challenges

Chudy-Laskowska describes the RFID tagging to be reliable and a system that consistently achieves the very best results\textsuperscript{3}. Although utilising this advanced technology may be beneficial, the most undesirable challenge is the cost of implementation in the process\textsuperscript{3,16}, especially in the case of DVI. Another challenge that Want discusses, is the need for acceptance of the new and advanced system\textsuperscript{16}. He proceeds to explain that it should be cautiously implemented in order to “incorporate safeguards” in the case of RFID misuse\textsuperscript{16}. A drawback as stated by Weinstein\textsuperscript{18} is that the storage memory of the RFID passive tag is relatively small, containing approximately two kilobits. However, he also indicates that as technology is continuously developing, the quantity of memory that a tag would hold, should increase significantly\textsuperscript{18}.

2.2.2 RFID applications

RFID tags have proven to be successfully implemented in businesses on a global scale, as stated by Chudy-Laskowska\textsuperscript{3}. Kantareddy et al. conducted a study where RFID tag-
sensors were put to use as an inventory, assisting in the process of keeping a count of the sharps that were utilised in the operating theatre\textsuperscript{17}. The intention of the research was to minimize the possibility of fortuitously leaving a sharp inside a patient, after surgery. The researchers demonstrated that the RFID system was reliable and has the potential to eliminate “manual intervention”, whilst reducing any possibility of error\textsuperscript{17}. Weinstein\textsuperscript{18} mentions several uses of RFID tags, and these include: “identification cards for building access, credit cards, or bus fares”. Tags may also be utilised on the rear of “labels printed on standard ink jet printers” \textsuperscript{18}. The purpose of this is for the placement of inventory\textsuperscript{18}. Weinstein\textsuperscript{18} describes where the RFID technology has been successfully implemented. Some of these businesses include: supply chain logistics for the tracking of products; security and identification, as mentioned above; and movement tracking – of humans.

RFID has become a useful system that has been applied to many areas of everyday life. Toll-payment transponders, libraries, passports and biohacking are amongst those areas mentioned by Juels\textsuperscript{19} and Yetisen\textsuperscript{4}. Juels\textsuperscript{19} states that RFID tags have been implanted in humans for the purpose of “medical-record indexing”. By scanning the tag on a patient, a hospital is able to locate the relevant records\textsuperscript{19}. Biohacking with the use of this RFID device has also emerged for the purpose of biometric animal identification, according to Yetisen\textsuperscript{4}. This author also noted that through the development of new and advanced RFID technology for animal tracking and identification, it had encouraged “self-experimentalists” to subdermally insert tags into themselves\textsuperscript{4}. The purpose of this was to interact with electronic devices such as computers\textsuperscript{4}.

Although the RFID device has some limitations, these can be avoided through careful consideration in the field of forensics and DVI. In the context of large scale DVI incidents, the tagging system has the potential to greatly decrease the valuable forensic
examination and identification time of victims. With the use of RFID, body parts can be tagged at the scene by investigators, details can be input, the remains could be packaged and dispatched sooner for further analysis. The technology is also likely to provide comprehensive information that will assist with the chain of custody. Hence, the use of RFID tags could substantially expedite the processing of human remains in large scale DVI incidents.

2.3 Forensics and RFID

Bode Technology, mentioned previously, is known to be a “forensic DNA services and products provider” that has successfully utilised the RFID system for the tracking of evidence and case files to improve “efficiency, accuracy and security” of forensic examinations and the chain of custody procedures. The Bode-RFID solutions include:

- Securely tracking evidence from the moment of collection at the scene and establishing electronic chain of custody through entering information onto a RFID reader/writer device.
- Reducing accessioning time, RFID tags are read on samples and are automatically identified, whilst the tagged badges of laboratory personnel are read by RFID readers. This maintains chain of custody.
- Identifying and collecting information from more than one sample for inventories.
- Alarms are activated in the event of items or personnel entering unauthorized areas.

Wessel describes how the Dutch Forensic Institute uses RFID to control crime scene evidence, where labels include an “embedded RFID tag, readable text and a bar-coded serial number”. Upon logging the evidence, a smaller label, with the same bar-coded number, is placed on the sheet. An automatic reading station that is similar to airport luggage scanners, is then utilised when the evidence arrives at the laboratory. The crime
scene exhibits would be transported on a belt into a portal that reads the RFID tags and the evidence is then photographed. Similar to Bode Technology\textsuperscript{7}, Wessel\textsuperscript{20} mentions that by determining the difference in read times, the system can calculate if an item of evidence was moved. Both articles\textsuperscript{7,20} have similar solutions to the control of evidence, and this includes the sounding of an alarm as evidence may be moved without permission in an unauthorised area. The Dutch Forensic Institute’s highest priority is not to determine an “estimated return on its investment”, but the improvement in integrity, the chain of custody and management of evidence\textsuperscript{20}.

In order to reduce the intensive and time-consuming labour that is involved in the process of DVI, as well as errors that are created by hand-writing, the RFID technology should be implemented at large scale disaster incidents. Through its use, the system could substantially expedite the processing of human remains and hence, positively identify a greater number of victims.

3. Experimental Design

3.1 Method 1: Dry Trial of Equipment

This test will be conducted to determine if a minimum of two hundred words can be input to an Allflex Microchip (RFID tag). Information such as the date, time, officer identification, GPS location/triangulation measurements, photograph references, identification/exhibit number, observation notes, and/or movement tracking, will be typed into the Virbac RFID read/write device. Further information will then be typed into the RFID read/write device, in an attempt to ascertain its overwrite capabilities and data storage limits. Observations will be recorded.
3.2 **Method 2: Mock DVI Scene**

An empty 3m x 3m room/demountable at Murdoch University will be utilised to simulate a DVI scenario and four pieces of animal tissue (beef) will be laid on the floor as “body parts”. The BackHome Mini Microchips (Virbac) will be sub-dermally inserted by an implanter into each animal tissue. The glass casing of the microchip ensures the low risk of contamination. The information, as mentioned above will then be typed into the RFID reader, for each microchip. The pieces of animal tissue will be packaged as per standard forensic DVI procedures and stored in the freezer of a Murdoch University laboratory at minus 4°C.

After one week the packages will be removed from the freezer and relocated to a laboratory bench. The animal tissue will be removed from the package and the RFID reader will be used to assess if the information on the microchip remains accessible, accurate and reliable. Based on the observations/results that will be determined from Method 1, further information may be input to the microchip from the reader device. Observations will be recorded in regard to the feasibility of the RFID tags and reader. The expense of the RFID technology will then be compared to its functionality. This method will be repeated twice for reliability.

4. **Project Aims, Objectives and Null Hypothesis**

4.1 **Research Aims and Objectives**

The objective of this study is to investigate the usefulness of the RFID technology for the expedition of human remain processing in large scale DVI incidents. The study intends to determine the feasibility and expenses associated with the use of RFID tags.
This aim can be further differentiated as:

1) To determine the feasibility of RFID tags for the expedition of body part processing in large scale DVI incidents, by conducting a dry test and mock DVI scenario.

2) To investigate the expenses associated with implementing the RFID technology in large scale DVI incidents.

4.2 Hypothesis

A sub-dermal RFID tag can be used in a mock DVI incident, utilising animal tissue (meat) that is laid across a 3m x 3m room, to store data (location, photograph references, identification/exhibit number, observation notes, and/or tracking) pertaining to the body part.

5. Conclusion

There are many scholarly articles that present detailed information on the DVI process, case studies, as well as information regarding RFID technology. However, very few papers discuss the need for further improvements on the expedition of body part processing in mass disasters. Winskog et al. \(^{21}\) explores the progression from disaster victim identification to disaster victim management as a “necessary evolution”. The legal responsibility falls on the investigators to positively identify every victim, to the best of their ability, for the sole purpose of returning the remains to their respective families\(^2\). The RFID tagging system has the ability to significantly decrease forensic examination and identification time of victims. It also has the potential to limit decomposition, as well as cross-contamination and disease\(^{1,13}\), whilst expediting the freezing process for the storage of remains\(^1\).
RFID has proven to be successful in several organisations on an international scale and has even been effective through sub-dermal implantation in humans as well as animals\textsuperscript{4}. Although the cost of implementing RFID is a limitation\textsuperscript{3}, it has demonstrated a high standard of accuracy and reliability in the field of forensics, as it has been utilised in the standard process of collecting evidence, inventories and the tracking of case files\textsuperscript{7,20}. This, in turn, maintains chain of custody. Implementing the RFID tagging system will essentially assist forensic investigators as well as legal authorities to expedite the DVI process and determine a greater amount of positive deceased victim identifications.
6. References

7. Industry G. RFID helps forensic analysis. Infotrac Newsstand. 2010


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Part Two

MANUSCRIPT

RFID TAGS FOR THE EXPEDITION OF BODY PART PROCESSING IN LARGE SCALE DISASTER VICTIM IDENTIFICATION INCIDENTS

A COST AND FEASIBILITY PILOT STUDY
Abstract

In the field of forensic science and disaster victim identification (DVI), a disaster is known to be an unforeseen incident that results in the demise of a mass of lives. Following these fatal events, DVI processes are conducted by investigators in order to identify the fallen victims, as this is the highest priority. The DVI Interpol Guide recognises that the general impression of an identification process is that it is time-consuming. Unfortunately, due to the general misconception of standard international procedures, families of those who have lost their lives in disasters tend to become disgruntled at the extensive time that is taken. The research gap remains in regard to how body part processing at large scale DVI incidents can be expedited. As such, this research aims to provide and investigate a potential solution for the timeliness response to mass disasters, and moreover allowing for a greater number of positive identifications. The project that was conducted also aimed to simplify the process of identification through sub-dermal implantation of microchips into human remains, using Radio Frequency Identification (RFID) technology. Implementing the RFID tagging system in a miniature scale trial, by inserting data and assessing its read and write capabilities, it has proven to be successful and will assist forensic investigators as well as legal authorities to expedite the DVI process and determine a greater amount of positive deceased victim identifications.
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List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>Ante-Mortem</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic Acid</td>
</tr>
<tr>
<td>DVI</td>
<td>Disaster Victim Identification</td>
</tr>
<tr>
<td>ICRC</td>
<td>International Committee of the Red Cross</td>
</tr>
<tr>
<td>PAHO</td>
<td>Pan American Health Organisation</td>
</tr>
<tr>
<td>PM</td>
<td>Post-Mortem</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
</tbody>
</table>
1. Introduction

Following several mass disasters, research within the field of forensic science and disaster victim identification (DVI) has concentrated on developing effective practical procedures in order to identify human remains. Majority of this research has involved improving technology and methods such as DNA analysis\(^1\). There are numerous documents that provide guidelines for procedures that should be undertaken in the event of a disaster\(^1\). Some of these handbooks include the National Institute of Justice\(^2\), the International Committee of the Red Cross (ICRC)\(^3\), and the INTERPOL DVI Guide\(^4\). Other reference guides (Bioterrorism Preparedness\(^5\), Tolley's Handbook of Disaster & Emergency Management\(^6\), and Disaster Victim Identification: The Practitioner's Guide\(^7\)) have been established for the purpose of informing, preparing and instructing authorities in the case that a disaster incident was to occur. Journal articles based on specific DVI events have been written, including ‘Forensic Anthropology in the United Kingdom – current trends, problems and concerns’\(^1,8\) however, a research gap remains in regard to how body part processing at large scale DVI incidents can be expedited. This project demonstrates that Radio Frequency Identification (RFID) technology shows promise in expediting the identification process.

In 2005, the Pan American Health Organisation (PAHO), the World Health Organisation (WHO), along with the ICRC, attended an organised meeting of experts to discuss and reflect on the lessons learned in the aftermath of the 2004 Asian tsunami\(^9\). After identifying the need for a simple and practical set of guidelines on the handling of deceased victims, the result was a manual on the ‘Management of Dead Bodies after Disasters’ for first responding officials or investigators\(^9,10\). There are three main pillars of
disaster response that have been recognised and made known by the humanitarian community. The first pillar is the “proper and dignified management of the dead”, the second is the “recovery and care of survivors”, and lastly, the “supply of basic services”. Disregarding any one of these core principles can potentially cause suffering to surviving family members.

At the aftermath of a catastrophe, the first response, in the initial hours, is generally conducted by members of the public community. In this time, the condition and handling of the deceased victims are of vital importance, as it may have a significant effect on the identification process. The DVI INTERPOL Guide, as well as the manual by PAHO complement each other, providing in-depth information for investigating officers as well as unofficial first responding individuals. The guides have been applied in disaster situations and have been beneficial towards the planning and preparation of response efforts. Additionally, after several DVI events, the manuals have been updated and revised with recommendations for future incidents.

Ellingham et al. notes that “in the event of a disaster, time is of the essence”. The ‘Management of Dead Bodies after Disasters’ manual provides a structured outline of the responsibilities that should be undertaken at the scene, including but not limited to: search and recovery, allocating unique numbers to remains or evidence, recording data, temporary storage of the deceased, as well as collecting and managing information of the missing individuals. In such environments, these tedious procedures may become overwhelming, even chaotic, and it is concerning that a more efficient and expeditious process has not yet been developed. This research aims to provide a potential solution for the timeliness response to mass disasters, by using RFID advanced technology.
The National Institute of Justice notes that it is imperative that laboratories have priority to access all the necessary data that relates to a deceased victim of a disaster\(^2\). This data should consist of DNA information or profiles, chain of custody documentation, and specific information that relates to an item of evidence\(^2\). The laboratories that conduct analyses of the human remains have a responsibility to make detailed and regular updates to the families of the deceased, the public, officials and authorities\(^2\). Additionally, forms including the Ante-Mortem (AM) and Post-Mortem (PM) documents must be completed with a high quality of detail\(^4\). The information of the deceased and results that are documented can however, be impacted by factors such as the exposure time and vulnerability to environmental conditions, as well as how decomposed the remains are\(^4\). It is therefore extremely important that the analysis procedures are conducted in a reliable and accurate manner. Implementing RFID technology aims to simplify the process of identification. The result of an accelerated forensic investigation could hence, prevent decomposition and relieve the suffering of bereaved family members.

The World Trade Center disaster of 2001, the Asian tsunami of 2004, the London bombings of 2005, and the Louisiana hurricane Katrina of 2005, are just some of the mass fatal incidents that have shown the world the difficulties that are encountered by forensic investigators\(^7,11\). For the purpose of identifying, locating and tracking people, animals or belongings, RFID technology that uses radio frequency has been utilised on a global scale\(^11\).\(^12\) In a typical set-up of an RFID system, the individual, animal or object is provided a tag (also known as transponder or microchip), that consists of an antenna coil, a memory chip, and a unique electronic code\(^11\). The RFID transceiver sends a signal that activates the transponder, in order for the data or information to be read or written to the chip itself\(^11\).
Transponders are known to be a “compact carrier of information” and can be sub-dermally implanted\textsuperscript{11}.

Biohacking has emerged for the purpose of animal identification, although recent research has suggested that RFID tags could be modified and embedded into the dental cavity of a deceased human\textsuperscript{11,13}. The transceiver would be able to locate, read and write to the transponder by moving the device over the cheek near the tagged tooth\textsuperscript{11}. This would prevent multiple microchips being signalled at the same time and would reduce the time taken to conduct forensic procedures\textsuperscript{11}. It also ensures that the data is encrypted and avoids costly procedures\textsuperscript{11}. In contrast to previous research and projects, an issue may arise if body parts become detached at the scene of a disaster. Other complications can include low quality samples of DNA, due to decomposition, along with the risk of cross contamination\textsuperscript{14}. Through implanting the RFID transponder sub-dermally, these potential risks can be significantly reduced. The remains can be packaged and dispatched sooner for further analysis, hence expediting the process of DVI.

The objective of this research project was to investigate the usefulness of RFID technology for the expedition of human remain processing in large scale DVI incidents. This was to be experimented through the sub-dermal implantation of RFID transponders into animal tissue in a mock DVI scenario. The study also intended to determine the feasibility and expenses that were associated with the implementation of RFID tags. The hypothesis was that a sub-dermal RFID transponder could be used in a mock DVI incident, utilising animal tissue (meat), to store data (location, photograph references, identification/exhibit number, observation notes, and/or tracking) pertaining to the body part. If successful, the RFID tags could be further validated in larger trials.
2. **Materials and Methods**

Two methods were to be conducted for this project. The first, a dry trial of the equipment, to determine if a minimum of two hundred words can be input to an RFID tag. Information such as the date, time, officer identification, GPS location/triangulation measurements, photograph references, identification/exhibit number, observation notes, and/or movement tracking, were to be typed into the RFID read and write device. Further information would then be typed into the RFID read and write device, in an attempt to ascertain its overwrite capabilities and data storage limits. Observations would then be recorded.

The second method was to be conducted in an empty 3m x 3m room/demountable at Murdoch University to simulate a DVI scenario and four pieces of animal tissue (beef) would be laid on the floor as “body parts”. The RFID microchips would be sub-dermally inserted by an implanted into each animal tissue. The glass casing of the microchip would ensure the low risk of contamination. The information, as mentioned previously will then be typed into the RFID read and write device, for each microchip. The pieces of animal tissue would then be packaged as per standard forensic DVI procedures and stored in the freezer of a Murdoch University laboratory at minus 4°C.

After one week the packaged would be removed from the freezer and relocated to a laboratory bench. The animal tissue would be removed from the package and the RFID reader device would be utilised to assess if the information on the microchip remains accessible, accurate and reliable. Based on the observations/results that were to be determined from the first method, further information would be input to the microchip from the reader device. Observations would be recorded in regard to the feasibility of the
RFID transponders and transceiver. The expense of the RFID technology would then be compared to its functionality. This method would be repeated twice for reliability.

The Atmel RFID Evaluation Kit (ATA2270-EK3) was purchased from the company Microchip Technology. This kit included the RFID read and write device (see Figure 1), along with several samples of transponders (see Figure 2).

Figure 1: The Atmel RFID read and write device, with antenna coil.
Figure 2: The Atmel RFID sample transponders.

The RFID read and write system, as seen in Figure 1, includes the ATA2270-EK3 main board, reader board, antenna coil as well as a power supply. Transponders A, H, I, and J of Figure 2 are known to be keyfob sample tags (ATA5577M1330C). Transponder B is an animal ear tag (ATA5575M2), and transponders C and K are contactless ISO cards (ATA5577M1330C). Sample tag D is a plastic encased transponder (ATA5577M1330C-PP). Transponder E is a tag that is suitable for the use of barcoding/labels. Sample tag F is another plastic encased transponder, whilst G is a glass encased microchip.

Due to the late arrival of the Atmel RFID Evaluation Kit, the procedures that were to be conducted were altered.

2.1 Method 1: Trial of Equipment

The first step was to ensure that the reader board was connected to the main board. The antenna air core coil was already wound on a plastic housing, to be then connected to the RFID transceiver. The power was connected using the supplied source.
and the evaluation kit was ready for operation by switching the power to the ON position\textsuperscript{15}. The F1-F4 buttons were used to return to the previous menu, whilst all other navigations were to be accomplished by using the four-way joystick. By pressing the centre of the joystick (“ENTER”), a command was successfully completed. When initially working with a transponder, the tag itself was to be placed into/surrounding the coil field, or in direct contact with the antenna coil. By choosing “RFID” on the transceiver, then the “Write Configurations Menu”, and selecting “Yes”, the transponder was to be recognised. When “Enter” was selected, the system would attempt to write the block data into the selected transponder.

\textbf{2.1.1 Writing to a transponder}

To ensure that the correct tag type was selected, “RFID>Select Reader/Tag” menu was accessed. The tag that was being evaluated was to be placed into the antenna coil field. The two antenna coils were placed parallel to each other in order for the magnetic field to couple and provide sufficient power\textsuperscript{15}. “RFID>Read/Write” was then selected, and then “One Block” in the Write column. Once the block was chosen, moving the joystick up or down would enable letters (A-F) or numbers (0-9) to be selected. By pressing “Enter” on the joystick, the blocks were exited. Pressing “Enter” once more ensures that the write was performed. A verification message would appear, and audio feedback would be provided. A message window would appear if the procedure was successful or unsuccessful\textsuperscript{15}. Transponders H, I and J (as seen in Figure 2) were allocated a “body part” number as though it would be designated to a deceased victim or item of evidence and had information typed into it, to determine if it could be read by the device. Each line in the RFID transceiver was given a specific piece of information, and a legend was created to indicate details, for each transponder.
2.1.2 Transponder I

Figure 3: Transponder I, designated to body part 1.
**Table 1:** Details of specific information for transponder I typed into the RFID transceiver.

<table>
<thead>
<tr>
<th><strong>Transponder I: Information</strong></th>
<th><strong>Block Detail</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Body Part ID Number</em></td>
<td>11111111</td>
</tr>
<tr>
<td><em>Date</em></td>
<td>10112018 (10th November 2018)</td>
</tr>
<tr>
<td><em>Time</em></td>
<td>00002220 (22:20)</td>
</tr>
<tr>
<td><em>Photograph Reference</em></td>
<td>DCC00001</td>
</tr>
<tr>
<td>- DCC = Photograph Reference Letters</td>
<td></td>
</tr>
<tr>
<td><em>Location</em></td>
<td>AE32B115 (-32°, 115 °)</td>
</tr>
<tr>
<td>- A = Latitude</td>
<td></td>
</tr>
<tr>
<td>- B = Longitude</td>
<td></td>
</tr>
<tr>
<td>- E = (-)</td>
<td></td>
</tr>
<tr>
<td><em>Investigating Officer Identification Number</em></td>
<td>33210058</td>
</tr>
<tr>
<td><em>Additional Information (If needed)</em></td>
<td>-</td>
</tr>
</tbody>
</table>
2.1.3 Transponder J

Figure 4: Transponder J, designated to body part 2.

Table 2: Details of specific information for transponder J typed into the RFID transceiver.

<table>
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<tr>
<th>Transponder J: Information</th>
<th>Block Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Part ID Number</td>
<td>22222222</td>
</tr>
<tr>
<td>Date</td>
<td>10112018 (10\textsuperscript{th} November 2018)</td>
</tr>
<tr>
<td>Time</td>
<td>00002249 (22:49)</td>
</tr>
<tr>
<td>Photograph Reference</td>
<td>DCC00002</td>
</tr>
<tr>
<td>• DCC = Photograph Reference Letters</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>AE35B117 (-35 °, 117 °)</td>
</tr>
<tr>
<td>• A = Latitude</td>
<td></td>
</tr>
<tr>
<td>• B = Longitude</td>
<td></td>
</tr>
<tr>
<td>• E = (-)</td>
<td></td>
</tr>
<tr>
<td>Investigating Officer Identification Number</td>
<td>33210058</td>
</tr>
<tr>
<td>Additional Information (If needed)</td>
<td>-</td>
</tr>
</tbody>
</table>
2.1.4 Transponder H

![Figure 5: Transponder H, designated to body part 3.](image)

Table 3: Details of specific information for transponder H typed into the RFID transceiver.

<table>
<thead>
<tr>
<th>Transponder H: Information</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Body Part ID Number</td>
<td>33333333</td>
</tr>
<tr>
<td>Date</td>
<td>10112018 (10⁰ November 2018)</td>
</tr>
<tr>
<td>Time</td>
<td>00002255 (22:55)</td>
</tr>
<tr>
<td>Photograph Reference</td>
<td></td>
</tr>
<tr>
<td>• DCC = Photograph Reference Letters</td>
<td>DCC00003</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>• A = Latitude</td>
<td>AE37B119 (-37 °, 119 °)</td>
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<tr>
<td>• B = Longitude</td>
<td></td>
</tr>
<tr>
<td>• E = (-)</td>
<td></td>
</tr>
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<td>Investigating Officer Identification Number</td>
<td>33210058</td>
</tr>
<tr>
<td>Additional Information (If needed)</td>
<td>-</td>
</tr>
</tbody>
</table>
2.1.5 Reading a Transponder

Once again, the correct tag type was selected through the “RFID>Select Reader/Tag” menu. The tag that was to be evaluated was placed in the antenna coil field, with the coil parallel as mentioned previously. “RFID>Read/Write” menu was selected and “Manual” in the Read column, was chosen. “Enter” was pressed to perform the read. Observations were made to ensure that the contents of the blocks were correct, and that audio feedback was provided. This would signify if the read attempt was successful or unsuccessful. A beeping audio feedback would indicate a successful outcome\textsuperscript{15}.

2.2 Method 2: Evidence Storage Simulation

Upon successful results from Method 1, the three RFID keyfob (ATA5577) transponders (H, I and J) were placed in a zip-lock bag (as seen below in Figure 6), and stored in a freezer, at minus 4°C, for two days. Once the tags were removed from the freezer, the information, as per section 3.1.5, was read through the transceiver. This was to determine if the read and write operations would be successful in changing temperatures and/or storage conditions.
3. Results and Discussion

The ATA5577 RFID transponders H, I and J, had a successful outcome and could potentially be utilised for the expedition of forensic investigations as well as the processing of large scale DVI incidents. Each of the sample transponders that were included in the Atmel RFID Evaluation Kit, were trialled for reading and writing operations. However, only three tags were successfully read through the transceiver device. There were several issues that were encountered during the process of this research project. Although, many of these difficulties could be overcome with additional time and functioning equipment.

The RFID transceiver device was to be connected to a power source, as well as a signal antenna coil. This was seen as a disadvantage for the initial purpose of this study, as
forensic investigators may not have a direct source of power to connect the transceiver. It also limits the distance that the transceiver can move. This means that any evidence or body part that is to be processed or read for information, should be in close proximity to the RFID read and write device. Similarly, each tag that was being assessed needed to be in the antenna coil field, or alternatively, in direct contact with the plastic housing of the coil. The transponders (A, B, C, D, E, F, G, and K) that were unsuccessfully written to and read, indicated several question marks in the blocks on the transceiver. A pop-up message also indicated that the transponders were “unsuccessful”. These issues could be solved for forensics, provided that the device itself was battery operated, and that all transponders were successfully operating.

Transponder G, as seen in Figure 2, would have been an ideal microchip to utilise for the initial purpose of this research, which was to expedite the identification process of deceased victims in the event of a disaster occurring. It is a suitable size for the sub-dermal implantation into human remains at a DVI incident. Also, its glass encasing would ensure a low risk of contamination. However, the RFID Evaluation Kit did not include an implanter for the microchip, and therefore the transponder could not be sub-dermally inserted into animal tissue. This transponder was also unsuccessfully written to and read, which further complicated the procedures that were to be undertaken in the first instance. Provided that the transponder itself was operating and an implanter was included, it would be a successful and suitable microchip that would potentially assist in reducing time and decomposition of remains at forensic DVI events, whilst allowing for a greater amount of positive identification of victims.

Another difficulty that was experienced in the process of this project was the information input. It was necessary to create a legend, as the device only accepts seven
lines of information per transponder. With this, each line has eight blocks available with letters ranging from A-F, or numbers 0-9. The information that was written to the successful transponders included the body part identification number, date, time, photograph reference, location, and investigating officer identification number. The seventh line could be utilised for additional notes that an investigating officer may want to record. With a limited range of letters and data storage, the DVI officers may encounter problems when creating addition notes. This could simply be resolved by allowing all letters of the alphabet to be used on the RFID device and adding a sufficient quantity of data storage to each transponder. Learning the legend and entering information that is to be written to a transponder, will become effortless with time and practice.

The RFID transceiver occasionally malfunctioned, which was a slight disadvantage, as the words on the screen were not easy to be read. This was not seen as a significant issue however, as the device could be easily reset with the press of a button. No information or data was lost at any point of this resetting process. The transceiver itself is efficient and is simple for any forensic officer to use. Also, the information that is input to the device, is secure in the data memory. This was noted as the successful transponders were read with the correct data in each line, ensuring reliability, confidentiality as well as encryption of information between each deceased victim.

Each of the transponders has the potential to be used in any forensic case, whether it be a DVI incident or a standard forensic crime investigation. Besides the use of the glass encased microchip being sub-dermally implanted in order to identify victims, each of the remaining transponders could potentially be utilised by simply inserting or attaching them into an evidence bag or case file for the purpose of tracking. This could ensure chain of custody from officers at the scene, through to attendance at court. Bode Technology have
successfully implemented the RFID system for the tracking of evidence and case files to improve “efficiency, accuracy and security” of forensic examinations and the chain of custody procedures. The Dutch Forensic Institute also uses RFID to control crime scene evidence, where the system can determine if an item of evidence was moved. Although the cost of the advanced technology is a drawback, the Dutch Forensic Institute indicate that their highest priority is not to determine an “estimated return on its investment”, but the improvement in integrity, the chain of custody and management of evidence. This should be considered in the field of forensic science and DVI.

Further experimentation using animal tissue in a mock DVI scenario, provided that an implanter is included, and the transponders are in working condition, can be conducted to sub-dermally insert microchips for the purpose of determining the usefulness of the RFID system. This should then be a timed experiment, including all transponders, which can be compared to the time taken at a standard forensic investigation. The outcome would determine the feasibility of RFID technology for the expedition of body part processing in large scale DVI incidents.

4. Conclusion

The DVI INTERPOL recognises that technology is continuously developing and as such, has enabled the operations and procedures to become increasingly effective. It’s also mentioned that such technologies cannot be a substitute for the experts and skills that are involved. However, this project aims to aid the expert forensic officers by employing technology that could potentially be utilised at DVI incidents.

RFID has proven to be successful in organisations and has been effective through sub-dermal implantation in humans and animals. Although the cost of implementing RFID
is a limitation, it has the potential to prevent decomposition, and has demonstrated a high standard of accuracy and reliability in the field of forensics, as it has been utilised in the standard process of collecting evidence, inventories and the tracking of case files\textsuperscript{16,17}. This, in turn, maintains chain of custody.

Finally, implementing the RFID tagging system will successfully assist forensic investigators as well as legal authorities to expedite the DVI process and determine a greater amount of positive deceased victim identifications.
5. References


