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# Mechanical Improvised Explosive Device Removal in the Urban Environment

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# MECHANICAL IMPROVISED EXPLOSIVE DEVICE REMOVAL IN THE URBAN ENVIRONMENT

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Health and Safety Management

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## DEDICATION

**2 Samuel 11. 22 – 25.**

*So the messenger went, and came and told David all that Joab had sent by him. And the messenger said to David, "Surely the men prevailed against us and came out to us in the field; then we drove them back as far as the entrance of the gate. The archers shot from the wall at your servants; and some of the king's servants are dead, and your servant Uriah the Hittite is dead also."*

*Then David said to the messenger, "Thus you shall say to Joab: 'Do not let this thing displease you, for the sword devours one as well as another. Strengthen your attack against the city, and overthrow it.' So encourage him."*

For all those who make the long lonely walk never to return…

…Costa, Chris, Andy…

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## ABSTRACT

The safe removal and disposal of conventional weapons from civilian populated areas in a post conflict scenario is fraught with dangerous, complex and wide-ranging challenges. The worldwide proliferation of improvised explosive devices has added to the existing burden of landmine clearance already being undertaken by various organizations. Part of the solution to these challenges is to remove improvised explosive devices using mechanical methods to reduce the likelihood and consequence of the risks that personnel face when carrying out this extremely hazardous task.

The mechanical removal of improvised explosive devices is an emerging methodology that is based on an established model of mechanical demining operations. While in a developmental stage, the author sought to engage with current practitioners, use recent personal experience and study the established demining model in an effort to shape the emergence and evolution of mechanical improvised explosive device removal in order to establish best practice guidance that could be shared within the conventional weapons disposal industry.

The results from this research study have identified focused topics that support an operational framework on which to base mechanical IED removal operations in the urban environment.

From this research study it is recommended that best practice guidance is used by organizations in the shaping of mechanical IED removal operations in the urban environment and that this best practice guidance is underpinned by a risk assessment giving consistency to safe working practices.

# CHAPTER 1: Introduction

## 1.1 Introduction

The purpose of this chapter is to demonstrate to the reader the motivation, background and focus for this research. This will include reference to the International Mine Action Standards (IMAS) which is the United Nations endorsed organization for global mine action. This demonstration will in turn support the research aims and objectives, which will be briefly explained in relation to the intended outcome. Next, the structure of this dissertation and how the research objectives will be achieved shall be explained and finally the benefit to operational practice will be demonstrated.

A glossary of terms is included at Appendix 4 to define and explain the technical aspects of the terminology and procedures.

## 1.2 Motivation and Background to Research

The safe removal of any Improvised Explosive Device (IED) is paramount. Traditionally this has been by human intervention within a range of training, techniques and procedures (TTP's) available to the operator.

There is current industry guidance in the form of IMAS 09.30 (IED disposal) and IMAS 09.50 (Mechanical demining). However, the author is suggesting the use of mechanical assets for IED removal is now a reality and best (safe) operating guidelines are a pertinent and immediate requirement.

In basic terms the demining operation is akin to agricultural harvesting where groups of deminers and or demining machines work in a grid pattern to clear a suspected hazardous area (SHA). This is opposed to IED removal which is point or location specific and an individual will clear up to and around an IED in order to defeat it. This can be a relatively quick operation or can last up to several days.

Part of the issue with IED removal is where the SHA is contaminated with mines, IED's and other explosive remnants of war (ERW) the TTP's require a more holistic approach. It is not always known what type of threat will be encountered in a SHA.

In a rural or farmland setting IED removal can be a relatively simple operation, the ground is more open for movement of deminers and demining vehicles with greater visibility of the population.

This research is focused on the urban environment which contains more complex factors to be considered. The roads and paths channel the organizations movement, the buildings can reduce visibility and make observation of the population more difficult. Further explanation of the urban environment will be discussed in Chapter 2.

### 1.3 Research Focus

The previous paragraph has shown that while there is current guidance for the removal of IED's and the operation of mechanical assets in a demining scenario, there is a gap in operating experience when it comes to the mechanical removal of IED's.

It is the focus of the author to bring together a number of operational threads that are currently being employed and formalize them into a usable and transferable set of guidelines for the employment of mechanical assets in IED removal. The ultimate outcomes being the safe mechanical removal of IED's with minimum human exposure to risk and the return of real estate within the urban environment denied to the civilian population back to productive use.

### 1.4 Research Aims and Objectives

The aim of this research is to examine the operation of mechanical assets for Improvised Explosive Device removal in the urban environment, in order to identify best practice guidance. The selection criteria for the selection of this aim is described in appendix 1.

The objectives of this research are:

Chapter 2 Literature Review:

1. Review a brief history of demining machines giving context of development and leading to an understanding of current employment of this equipment.
2. Examine the current operation of mechanical demining machines.
3. Examine future developments and integration of current technology.
4. Define the urban environment.

Chapter 3 Methodology:

5. Using appropriate techniques identify and select a data subject population.
6. Employ an interpretive, qualitative model of research to build a persuasive body of evidence to support the achievement of the aim of the research.

Chapter 4 Primary Source Findings:

7. Gain operational opinion from current practitioners of IED removal in the urban environment.
8. Analyse primary data and secondary data in association, in order to facilitate the synthesis of conclusions from this analysis.

Chapter 5 Conclusions and recommendations:

9. Suggest a method of operation for mechanical assets.
10. Explain the need for this method of operation.
11. Suggest methods for the integration of technological advances.
12. Discuss logistical support and considerations for mechanical assets.

### 1.5 Research Structure

This research will be accomplished through the framework of five chapters, the format of which is shown below.

Chapter 1 – Introduction.
A brief introduction to the research material and the motivation for undertaking the research. The aims and objectives are described, the research structure is explained and the ultimate outcome stated.

Chapter 2 – Literature Review. Research Objectives 1, 2, 3 & 4.
A study of relevant published literature is undertaken to fully understand the historic and current guidance and employment of mechanical equipment and the evolution into use for IED removal. Initial interim findings will be articulated.

Chapter 3 – Methodology. Research Objectives 5 & 6.
This defines the research strategy to collect primary data, the rationale of sampling from the data population and the pilot study will also be explained.

Chapter 4 – Primary Source Findings. Research Objectives 7 & 8.
A multi variant analysis of the primary and secondary data will be undertaken in order to: Develop the initial findings generated from the literature review, check any gaps in knowledge from current practitioners, gain operational opinion, examine the relationship of the association of variables.

Chapter 5 - Chapter 5 Conclusions and recommendations Research Objectives 9, 10, 11 & 12.

This final chapter will establish if the research aim has been achieved by reviewing the outcomes of the previous chapters. Conclusions and recommendations will be presented with full evidential justification. The final chapter will also identify lessons learned during the research process and how these may be used to improve the authors professional practice.

### 1.6 Value of Research

This research takes the existing guidance available through IMAS and through a process of synthesis of available secondary data and collected primary data is intended to develop best (safe) operational guidance which removes or minimises human involvement in the mechanical neutralization of IED's in the urban environment. This guidance is intended to be transferable globally with adjustment made for the specific urban environment that is being operated in.

### 1.7 Concluding Remarks

Chapter one has described the motivation, background and focus for this research. A set of objectives and research aim has been identified with a research structure to support this has been explained. The next step in the process is a planned and systematic review of the relevant literature available.

# CHAPTER 2: Literature Review

## 2.1 Introduction

Chapter 2 is intended to accomplish research objectives 1, 2, 3 & 4 as described in chapter 1. This will be achieved by a planned and systematic review of current literature guided by the hierarchy of research as shown in Appendix 2. This will involve a review of pertinent material from which to gather data, identify variables and process these into information to be analysed from which initial findings will be drawn.

## 2.2 A Brief History of Demining Machines

To understand how mechanical assets are currently employed in demining and where they may be practically employed in IED removal the evolution of the demining machine must be understood. As Lodhammer (2008/9, p. 70) writes, and is paraphrased by the author:

*The demining machine was introduced circa 1942 by the British Army and was essentially used as a tool to breach a lane into and through a minefield.*

These machines were military tanks (Matilda's) with a flail system (a rapidly rotating, independently driven axle with weighted chains attached) fixed to the front of the tank to thrash the ground in front of them and detonate or break up any landmines in their path. These demining machines met with limited success and improvements were steadily introduced, thus the evolution of demining machines had begun.

Demining remained within the confines of the military until the 1990's when non-governmental organisations (NGO's) and commercial demining organisations started to use this technique. This coincided with the 1997 Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction. There is no implied or assumed association of these events by the author.

Currently there are three categories of demining machines (International Mine Action Standards, 09.50, p. 2, 2013):

*…those machines designed to detonate hazards, machines designed to prepare the ground, and machines designed to detect hazards.*

The downside of this evolution was the cost of either converting existing ex-military, agricultural and industrial machines or the inception, production, testing and deployment of purpose built demining machines. As costs of demining were scrutinised by donors of funding to the projects (these are usually governments and charities who provide funding), they expected to see faster and more effective clearance times and thus the return of land to productive use. Although undefined by IMAS, returning land to productive use is clearing land of explosive remnants of war so that the original owners can resume whatever activity was occurring prior to the explosive contamination. This could be agricultural or providing community services, for example water treatment plants.

There is a cost comparison of manual demining versus mechanical demining in Farmland made by Schoeck (2000, p. 91-3) and while the author of the paper acknowledges a number of assumptions, in Table 1 below, is a basic formula that can be applied across all explosive remnants of war (ERW) operations.

**Table 1. Cost Comparison.**

| Mechanical | Manual |
|---|---|
| *Time, area cleared ($m^2$) x unit cost of machine.* | *Time, area cleared($m^2$) x unit cost of workforce.* |
| *9$km^2$ – 15$km^2$ x market price of contract = 40 cents per $m^2$.* | *6,000$m^2$ – 18,000$m^2$ x \$10,000 = 57 cents per $m^2$ - \$1.70 per $m^2$.* |

This demonstrates that mechanical demining can be a cost-effective method of clearing suspected hazardous areas (SHA).

### 2.3 Current Operation of Machinery

The author's operational experience and understanding for the use of machinery in IED removal is to: Minimise human risk, defeat the device, maximise land use, reduce time spent on task and minimise project costs.

As will be discussed later in the chapter there is a variety in IED componentry and emplacement. A detected IED will be subjected to an operational assessment for suitability for mechanical removal, the type of IED will determine what form of intervention against component parts can be considered. This could include a water charge (high pressure water fired explosively) used against electrical components or a cutting hook used to sever cables and wires.

The IED removal machine will be manoeuvred into a safe position and the selected tool placed close to the component part to be defeated. The disruption to the component part will be initiated and once completed an assessment of success of the defeat of the device will be made, this could be by CCTV or by human observation. If the IED is considered defeated, then the safe clearance of the remaining components may be completed.

As discussed previously demining machinery can fulfil three functions (ground preparation, detection and detonation). For the host nation mine action authority (HNMAA) and local population to have confidence in the machinery IMAS have developed a test and evaluation protocol for machinery that is involved in the detonation function.

IMAS and The European Committee for Standardization (CEN) Workshop Agreement (CWA) in collaboration with other stakeholders have produced guidance in the form of Test and Evaluation Protocol (2009) (T&EP). However, as stated on page 4, it is important to note that:

*This CEN Workshop Agreement can in no way be held as being an official standard developed by CEN and its members*.

What the Test and Evaluation Protocol (2009) (T&EP) does provide is:

*…a standardized methodology framework for performance, survivability, acceptance and test targets.*

The performance and acceptance criteria are technically straight forward but issues arise when addressing the criteria of survivability and test targets.

Survivability is the degree of operational function that remains in the machine post blast, this includes protection to the operator. The expected area of blast is at the point where the machine tool is in direct contact with the explosive device. For demining machines this can be complicated by mines being kicked out of the clearance area by flails, or caught up in the tooling, for example trapped between tiller blades. It is also possible for the machine tools to miss mines and the wheels or tracks of the machine to then detonate the mine, or for the mine to pass undetected by the machine. This is part of the quality assurance/quality control (QA/QC) process and will be discussed later in the chapter.

### 2.4 Testing Demining and IED Removal Machinery

Demining machines are tested against the worst-case scenario for that machine, this is a mine detonation under the operator compartment, with the explosive load not exceeding the design of the machine. The fill of the test mine is consistent and is TNT or an equivalent explosive. This where a departure from using machinery for demining and using machinery for IED begins.

A characteristic of the IED is that its' Net Explosive Quantity (NEQ) is unknown and can only be estimated, this could be for the following reasons:

- The explosive fill may be non-commercial or "homemade",
- The ingredients of the explosive fill may be poor quality,
- The component parts may not function as intended,
- The experience of the IED maker,
- There may be an additional commercial charge, this is a factory produced explosive used by the IED maker to improve the chances of detonating a homemade explosive fill,
- The explosive fill may be degraded due to exposure to the elements or time,
- The size of the container may be unknown.

The method of operation of the machine is different in IED removal as opposed to demining. As mentioned previously a demining machine acts in an almost agricultural manner working a grid pattern in an area clearance, where as an IED is usually at a specific location, though this is not always the case as IED belts may be laid.

Remotely operated machines can be operated in areas with larger yield explosive charges. However, this has potential for the machines to be destroyed in a detonation or to be temporarily removed from service due to damage or for a post blast inspection.

This indicates to the author that an acceptance test is also required for IED machinery. However, the test criteria must be separate from the de-mining requirements as the employment of the machines if different.

Currently, demining machines are manufactured commercially or existing agricultural and industrial machines are modified to fit the role they are intended for (ground preparation, detection and detonation). At present there is limited commercial IED removal machinery available, this means that demining machines are sometimes used and modified, or existing

agricultural and industrial machines are modified. The modifications to either demining or agricultural and industrial machines can include:

The addition or improvement of vehicle armour to protect against explosion, fragmentation or blast shockwave.
Fitting of CCTV cameras to improve observation.
Remote control operation units, to remove the human operator from the vehicle.
The addition of modular tools.

As IED removal does not include any of the three functions of demining (ground preparation, detection and detonation), the tooling requirement and basic operation is very different.

**2.5 IED Component Parts**

For the test criteria to be understood the requirement of the machine and its intent must also be understood. The machine is intended to defeat an IED, in an ideal situation rendering harmless and without the IED functioning.

An IED is made up of: A switch, power source, initiator (including detonator), container and main charge, all IED's are detonated by: a victim, by command from the perpetrator or by a timer. It should be noted that the nature of an IED means some of these components and means of detonation may be absent or linked to other IED's (daisy chaining).

Furthermore, there are many variations of the component parts of an IED. Switches may be sensitive to light, pressure, heat, movement, electromagnetic energy or sound. Switches may also be operated remotely by command wire, radio (open frequency or encrypted), cellular telephone, collapsing electrical circuit, tremble switch or any other method designed by the IED maker.

Power sources can be alternating current (AC), direct current (DC), solar, mechanical or chemical.

The initiator or the detonator (blasting cap) may be commercially produced and electrical or chemical in design, alternatively the detonator may be manufactured by the IED maker using either an electrical or chemical design or another heat source as method of initiation.

The container can literally be any item containing a void from a child's toy to a motor vehicle.

For the IED removal machine to have achieved a recognisable level of success against the IED it must be able to safely neutralise the IED in what is known as a render safe procedure (RSP), as opposed to the device being blown in place (BIP). If a device is BIP'd then effectively the work of the insurgent/terrorist has been done for them by the clearance organization and there is the real probability of alienating the local population.

**2.6 IED Search**

In mine action (MA), searchers have a very linear grid pattern that is essentially two dimensional, while maintaining a three dimensional situation awareness. The primary method of detection in MA is a detector, usually hand held that alarms to ferrous readings from the ground.

In IED search, searchers work very much in a three dimensional environment with the primary method of detection being visual and physical, while detectors are used it is more for the confirmation of the discovery of likely component parts.

The military utilize four basic elements in counter IED operations Gade (2018, p 47):

*Attack the Network; Prepare the Force; Defeat the Device; and Exploit the Incidence.*

The civilian and commercial companies operating in the IED removal theatre do not need to consider all the factors that affect the military and an equivalency is described below. No description of the military terminology is given in order to protect the security of military operations.

The application of the concepts below is to provide a consistent structure to IED removal operations, inform the risk assessment and information gathering process, consider what positive action (render safe procedure or blow in place) is most appropriate, consider forensic recovery and improve operational knowledge.

Attack the network.

**Detect** the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties or by searching of the suspected hazardous area (SHA).

Prepare the force.
**Defeat** the component parts of the IED in a render safe procedure only resorting to blowing in place when no other options are available.

Defeat device.
**Dispose** of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.

Exploit incidence.
**Divulge** from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority component parts and reports as required.

### 2.7 Suitability of IED for Mechanical Removal

In order for safe and appropriate IED removal with mechanical means, there are a number of factors that need to be considered as there are with mechanical de-mining operations.

Only victim operated IED's (VOIED's) should be considered as suitable candidates for mechanical removal as command and timer operated IED's are considered to be too high risk for civilian or commercial operations and are best left to the Military, Police or other suitable host nation agency to deal with. This is because command or timer initiated IED's are considered to have an active operator (insurgent, terrorist or enemy soldier) waiting to detonate the IED.

The type of switch must be considered as this is the primary means of detonation of the IED. Previous field reports completed on the project, witness descriptions and operators search will all contribute to the assessment of what type of IED and associated component parts are being detected and defeated. A power source for an IED is generally in the form of a battery pack but there may be back up power sources and or multiple battery packs contained within the IED. The manufacture, composition, construction and reliability of the detonator or initiator the must be considered.

The IED container should be suitable for lifting, dragging, hooking or any other mechanical movement. This can include human remains as suicide vests are frequently found on deceased individuals.

The net explosive quantity of the main charge must be considered in regards to the type of machine that is conducting the IED removal operation. While the expected point of detonation should be where the machine tool makes contact with the component to be defeated, this cannot be guaranteed and the worst case scenario of a detonation underneath an occupied operator area must be considered.

Sympathetic detonation is when the shock wave through air or fragmentation from an explosive device (IED or commercially manufactured) impacts on another device which is close by to the original detonation and then functions as intended. Another issue to be considered is falling debris onto another device, in a densely contaminated ERW area this can have a high level of likelihood. The kick out of materials from explosions can make this an extremely unpredictable event and even though the likelihood can reduce further away from the original explosion, the consequences remain just as serious.

In the author's experience the above factors are routinely considered on operations, the author believes that a formal risk matrix and process will add clarity and consistency to the decision to use mechanical means for IED removal. This formal risk matrix will be included in the best practice guidance which will be the outcome of this research project.

### 2.8 Future Developments and Integration of Current Technology

Drones (unmanned aerial vehicle (UAV)[1]) and remote controlled land vehicles (unmanned ground vehicle (UGV)) can offer an opportunity to remotely view the IED in situ without the need to have an operator approach the device until a visual reconnaissance has taken place. Improvements in image quality and connectivity are increasingly negating the requirement to have a communications cable trailing behind a remote vehicle and allowing cameras to be mounted at the machine tool face.

The classic image of a tracked remote vehicle about the size of a wheelbarrow approaching a suspect vehicle on an urban street is in reality a rare event. With the vehicle cost at approximately $150,000 upwards mistakes can be extremely costly to a clearance project. The position of the IED must also lend itself to reconnaissance by this method. Stairs, rubble, ditches and berms[2] all add to the issues of access for UGV's in the urban environment.

[1] An unmanned aerial system (UAS) includes the ground-based control centre.
[2] A ditch and berm is a typical defensive system usually surrounding a compound or critical infrastructure.

Flying a UAV is skill that not all searchers or IED operators can master, weather conditions, debris and dust can all impede UAV use, while UAV's can be relatively cheap, all crashed UAV's must be recovered so that they cannot be used against the clearance teams.

Recent times have seen an increase in aerial delivery systems for IED's, the explosive remnants of war community is crystallising definitions but in outline terms IEDs may be delivered by rocket (in the way Hamas launch into Israel for example), be rocket assisted (shoulder launched like an RPG), be projected (an improvised mortar) or air dropped from a UAV.

As Rufas (2017/2018, p. 48) states.

*It does not matter how they could be named, but the UAS armed with warheads have the opportunity of modifying some aspects of current warfare.*

It is possible to make full sized plant or other agricultural and industrial machinery into remote controlled units. The problems of operation involve the communication link, observation of the vehicle, observation of the suspected hazardous area or IED and the protected positioning of the operator.

For IED removal machinery to remain cost effective to the projects and explosive remnant of war clearance industry in general the equipment must remain affordable, be able to be easily upscaled to cope with increased operational requirements, have the ability to be modular in regards to the tool machine interface so that one IED removal machine may have many practical applications and be adaptive to the environment that the IED removal machine is operating in.

**2.9 Definition of The Urban Environment**

In military parlance the battle space has evolved from binary conflict (combatants and non-combatants) into what is now known as an asymmetrical conflict or a three block war. This is where three differing types of operation can be experienced within three city blocks as first described by the United States Marine Corps, Krulak (1999):

*…the three block war -- contingencies in which Marines may be confronted by the entire spectrum of tactical challenges in the span of a few hours and within the space of three contiguous city blocks.*

In practical terms this is conventional war fighting between combatants (insurgency/terrorism can be included in this category), peace keeping and humanitarian relief. This initial definition has now evolved into what is known as asymmetrical conflict.

This leaves a moral conundrum and practical problem for clearance teams operating in the urban environment. The clearance teams cannot and must not be viewed as taking the side of one or more factions and must engage not only with the home nation mine action authority (HNMAA) but also the local population. The tasking system for clearance must be defined, structured and transparent to all interested parties. This can be considered within the mechanical suitability matrix and given as guidance to the HNMAA.

Mechanical clearance machinery and plant is high value equipment that HNMAA, donors and the local population expect to be seen working as frequently as possible, as was illustrated earlier in table 1, as mechanical clearance rates can far exceed human based clearance rates.

Traditionally clearance rates are measured in $m^2$ in the largely rural settings in which clearance teams operate, this also applies to the urban environment, even though the setting is very much more three dimensional. This raises the question of why clearance rates are not measured in $m^3$? This would more accurately reflect the search pattern of the teams and be more descriptive of the actual volume of area cleared by all assets, including mechanical.

**2.10 Tasking System for Clearance**

As mentioned previously the tasking system for clearance must be transparent. This tasking system is a method for ensuring that critical infrastructure, be that water treatment plants, hospitals, schools, etc. is suggested by the local authority, agreed by the project financial donors and has practical input from the clearance organization. These checks and balances help to prevent the misuse of assets and accusations of favouritism within the local community.

While every HNMAA has its' own system the basic minimum tasking criteria should include:

- Target location.
- Priority of clearance.
- Land owner or point of contact.
- When the task was reported.

- What hazards are present or suspected.
- Who will acceptance the cleared target on task completion.

Single item explosive remnant of war stand alone tasks are understood as spot tasks, although not defined by UNMAS.

Confirmed Hazardous Area (CHA) refers to an area where the presence of explosive ordnance contamination has been confirmed on the basis of direct evidence of the presence of Explosive Ordnance (see glossary of terms).

As alluded to by McInally and Risser (2018 p36) there is an emerging model of area clearance following the idea of:

*Clear the school, clear the road and clear the home.*

This is a deviation from the traditional mine action ethos and makes sense in the urban environment. This again is worthy of consideration in the tasking system for clearance.

### 2.11 Quality Assurance Quality Control

Within the industry the quality management plans including quality assurance & quality control (QA/QC) are based on International Standard Organization (ISO) 9001. In day to day operations quality management is known as “QA/QC” regardless of which function is being carried out. Without becoming drawn into a quality management side issue, the salient point is that a QA/QC process takes place after a CHA or IED has been removed and prior to land being released back to the owners. There are a number of techniques that may be used to perform the QA/QC but the key is that the QA/QC process is carried out as independently as possible and the end result is that land is declared safe.

Although not specifically mentioned in this chapter or study, machine operator and end user training is an implied action throughout the process of IED removal in the urban environment. This subject has deliberately only been very briefly discussed to avoid distraction from the main area of research.

### 2.12 Interim Findings

1. Mechanical assets can be a cost-effective method for the removal of IED's. However, procurement and logistical support are an expensive initial outlay. (Para 2.2).

2. As mechanical demining has evolved, a similar model can be applied to mechanical IED removal, this can be used to guide and influence the usage of machines and give direction to manufacturers. (Para 2.2).

3. A test and acceptance protocol for machinery used in IED removal should be developed, in much the same way that demining machinery is tested. This will add to the confidence of operators, the HNMAA and the civilian population. (Para 2.3).

4. The IED removal machine should be able to operate without inadvertently activating or destroying IED component parts, in order to complete a render safe procedure. (Para 2.4).

5. Any mechanical IED removal should aim to support the fundamentals of IED operations. (Para 2.6).

6. IED classification system, a mechanical suitability matrix may be beneficial to formalise the classifications of IEDs and their suitability for removal by mechanical means. (Para 2.7).

7. Machinery should be affordable, scalable, modular and adaptive in order to keep pace with technological advances. (Para 2.8)

8. The current system of reporting $m^2$ does not accurately reflect the operational environment in the clearance of an asymmetric, urban IED suspected hazardous area. (Para 2.9).

9. The tasking system for clearance must be suitable for the theatre of operations, responsive to the threat and risks prevalent, compliant with HNMAA standards and international requirements and engender confidence in its application. (Para 2.10).

10. Mechanical IED removal must be able to match the other methods employed by clearance teams in QA/QC terms. (Para 2.11).

### 2.13 Concluding Remarks

This chapter has examined objectives 1, 2, 3 and 4 within the available published literature. The emergence of mechanical IED removal is a relatively new concept that is developing as IED proliferation becomes more widespread, as such it is embryonic in its operational employment. The author intends to investigate further the interim findings taking the interim findings and adding operational opinion and experience gained from his own experiential knowledge and a programme of written interviews conducted with individuals who are currently operating in the urban IED removal theatre to form practical and robust guidance.

# CHAPTER 3: Methodology

## 3.1 Introduction

Research objectives five and six will be addressed in this chapter. That is to:

Use appropriate techniques to identify and select a data subject population.
Employ an interpretive, qualitative model of research to build a persuasive body of evidence to support the achievement of the aim of the research.

The aim of this research is to examine the operation of mechanical assets for Improvised Explosive Device removal in the urban environment, in order to identify best practice guidance.

In order to achieve these research objectives, the research approach will be based on the research onion (Saunders, et al. p.108 2009). The key stages of this approach being:

Philosophy.
Approach and logic.
Data collection strategy.
Data population.
Data size.
Data sampling.
Data collection instrument.
Data collection analysis.
Bias.
Pilot study.
Pilot study feedback.
Written interview questions.
Ethical considerations.
Research logistics.
Time management.
Participants.
Unforeseen events.

This is deemed to be an appropriate and effective research approach supporting the research objectives and the research aim of providing best practice guidance.

### 3.2 Research Approach

The initial findings described in chapter two establish an academic basis for the prosecution of the aim of the study, but practical experience and understanding of the process of mechanical IED removal is required to fully inform and develop best practice guidance. This knowledge gap in understanding will be bridged by the collection of primary data synthesised with the established secondary data.

### 3.3 Philosophy

Due to its dependence on quantifiable data and statistical analysis Positivism is not considered to be suitable philosophy for this study.

As the data population will be asked for human experience and opinion, not the separation of independence from the mind Realism is not considered to be suitable philosophy for this study.

Within Interpretivism observation and interviews are the basis on which primary data is gathered for the researcher to then interpret in a qualitative manner. This allows respondents to reply with a degree of honesty and candour that can provide a deep insight and a wealth of context, adding validity to the overall study. Respondent bias is a consideration that must be taken into account.

### 3.4 Approach and Logic

As there will be no hypothesis articulated at this stage deductive reasoning is not an appropriate approach to take.

The aim to develop best practice guidance is an evolutionary process that takes the initial findings of the literature review, the responses to questions and the authors experience to lead to a results based set of conclusions. This inductive reasoning approach best suits this research study.

### 3.5 Data Collection Strategy

In the formation process of the data collection strategy the author considered what data was required for the research study, how best to collect that data and who that data would be collected from.

With the literature review completed the next stage of the process was to collate the opinions of current practitioners and understand the operational experience of what processes are actually being carried out currently.

### 3.6 Data Population

Before any questions could be asked the data population had to be identified. The selection criteria for the data population is described below and is generated by the author's operational experience.

The respondent must have been involved in an explosive remnant of war clearance operation within the last two years. This gives the respondent current experience and adds to the credibility of their responses.
The respondent must have been involved in explosive remnant of war clearance operations that had operated in an urban environment. This is the area being studied and while rural operations are equally as important the focus of the author's study is the urban environment.
The respondent must have the time, capability and desire to take part in the study.

### 3.7 Data Size

The selection criteria for the data size is largely driven by two factors. The requirements of the university to ensure academic rigor and those individuals who are actually working in the industry and comply with the criteria to take part in the research study. Explosive remnant of war clearance contains a number of specialisms including anti-personnel and anti-vehicle mine removal, battlefield area search and clearance, explosive ordnance removal and IED removal. The worldwide populations of these specialists are low in numbers.

The author contacted 21 individuals informally as part of the research logistics phase to gauge if there would be a suitable response from individuals who would meet the selection criteria. All responded positively.
The basic requirement from the university was 15 respondents. In order to allow for those who could not take part after the initial positive replies, an additional six individuals were considered to be a sufficient reserve to allow for a wastage rate.

### 3.8 Data Sampling

The method of data sampling is purposive as the judgement of the author is being used in generation of the selection criteria of participants and the size of the data population is limited. This can be further categorised as Homogenous sampling as a particular subgroup are being actively sought to take part in the research study.

The selection criteria for this study's purposive sampling is as described below.

- The respondents should be experienced in the task of mechanical IED removal in the urban environment. This individual experience will be established by virtue of the job position and job description of the individual.
- The respondents should be knowledgeable in the task of mechanical IED removal in the urban environment. This knowledge will be demonstrated by being involved in mechanical IED removal in the urban environment within the last two years and showing a work history of this type of work.
- The respondents should be available to complete the written interview within a reasonable timeframe in order for the results to be analysed.
- The respondents should be able to communicate their opinions and experiences within the parameters of the written questionnaire.

To the advantage of the author this is a cost effective and time saving method of gathering primary data from a limited number of operational practitioners who fit the selection criteria.

Areas that might disadvantage the author are a bias of the respondents in their replies and the bias of the author in the interpretation of those replies. Additionally, there may be difficultly in identifying thematic threads in the responses.

### 3.9 Data Collection Instrument

A number of practicalities influenced the selection of the data collection instrument, global geographical locations of respondents, different time zones of respondents, the operational tempo for those respondents deployed on current IED removal projects and the desire of the author not to intrude into respondents time at home with families.

For the reasons mentioned above interviews either face to face or by video link were not considered to be a practical method of obtaining primary data. As the author is currently not deployed in an operational capacity, a field study was also not considered practical method of obtaining primary data.

A questionnaire was considered although the potential for responses was deemed to be limiting to the respondents where a fuller and deeper explanation could provide more useful primary data to the research study.

A written interview was selected as the most appropriate data collection instrument. The questions generated would be derived from the gaps in knowledge identified after consideration of the initial findings articulated on the completion of the literature review. The construction of the questions was open in order to allow the respondents scope to fully respond according to their opinion, knowledge and operational experience.

### 3.10 Data Collection Analysis

The qualitative data collected would have to be meaningfully analysed for the results to be able to be used effectively when drawing out conclusions and making recommendations using this primary data.

This will be achieved by identifying thematic pillars that emerge from the written interviews and interpreting these thematic pillars into conclusions.

The issue of who to gather data from and how to gather the data was resolved by using a written interview. This was decided on as being an appropriate method to ensure reliability, as the written interview could be used again with a different set of respondents and to achieve validity as the written questions have come from the secondary data.

Prior to the type of research being determined consideration was given to data and its evolution to usable understanding that can be used to create best practice guidance. How the data will be collected, measured, analysed and presented for synthesis with the secondary data were areas that were considered.

A set of operational definitions was determined that will be used in this research study and are illustrated below (Fricke, M. 2018)[3]:

[3] The origin of the Data, Information, Knowledge, Wisdom hierarchy is traced to T.S. Eliot's 1934 pageant play The Rock.

*Where is the wisdom, we have lost in knowledge? Where is the knowledge, we have lost in information?*

However, Eliot does not claim authorship of the entire play and so cannot be credited as the main source. The hierarchy of knowledge has had much input and attempted definition, naming and renaming so that its origins and contributors become unclear.

In the interests of academic rigor the author credits Fricke M as the collator from where the author developed the definitions specific to this research study.

*Data, information, knowledge, wisdom.*

Data. In the collection of primary source data individuals will be asked investigative questions in the form of a written interview. This will involve these individuals making subjective replies to the questions raised, this is a desired outcome from the data collection process as experience and opinion are what is being sought.

Information. The collected data will be subjected to a level of analysis which makes that data exploitable to the study. This where the thematic pillars will be identified. At this stage the subjective data becomes usable information. The analysis of the data and information provides the “what actions” are being done.

Knowledge. This usable information can now be organised into operational knowledge. That is knowledge which can be productively used to shape the understanding of that which has been received in order to identify the “how actions” are being done.

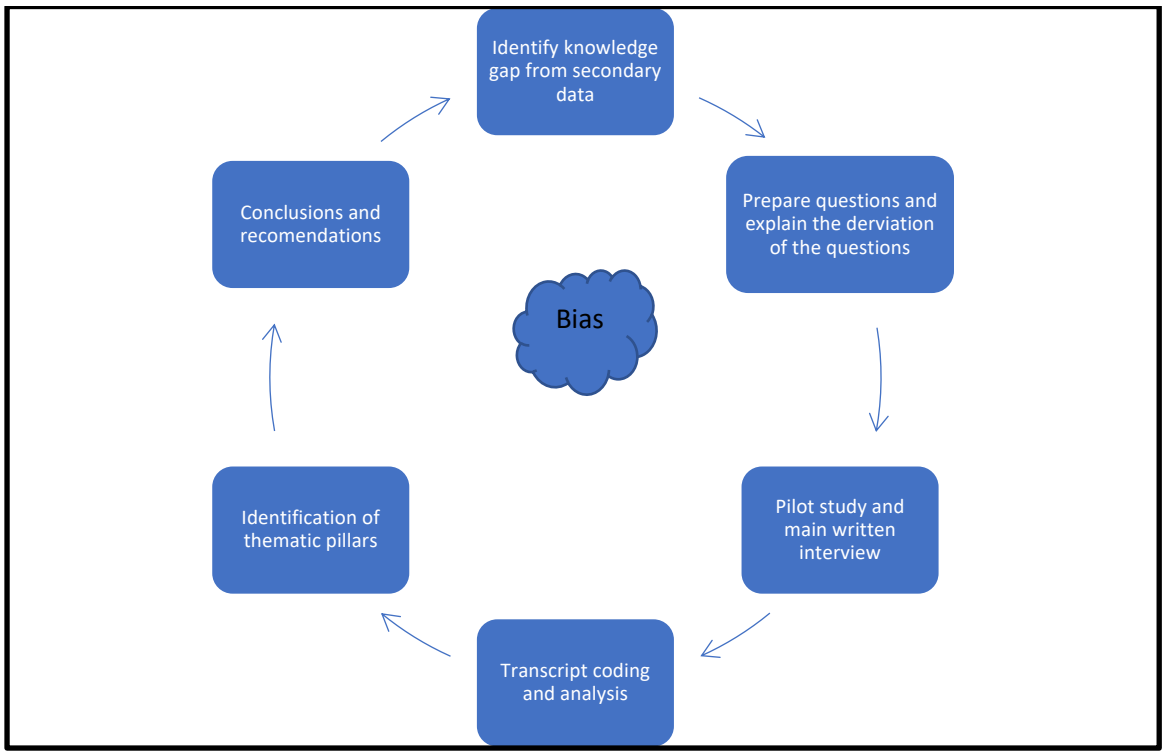
Understanding. This operational knowledge can now be used to provide a practical application of data, information and knowledge combined into an understanding of “why and when” actions are being done.

### 3.11 Bias

The author is aware of the possibility of bias in the construction of the written interview, the selection of the data sample being chosen from those who might have similar views and questions to the author and during analysis to reinforce the view and opinions of the author. To counter this in the first instance the author is aware of the possibility of bias. The methodology of the study is clearly and transparently explained so that it avoids systematic bias in data sample selection and asks in the written interview for personal opinion and experience.

The primary data collection process is shown diagrammatically below in Fig 1.

**Fig 1. Primary Data Collection Process.**



### 3.12 Pilot Study

A pilot study was conducted to examine the feasibility of the written interview to ascertain if the format allowed the respondents to fully explain their opinion and be able to describe their experiences clearly so that an analysis could take place to identify thematic pillars.

The respondent for the pilot study was selected for his management position, operational experience, particularly in mechanical IED operations and his gravitas within the industry. The aim being to receive pertinent and effective feedback that would benefit the full study when it was distributed to the larger group.

### 3.13 Written Interview Questions

The written interview questions are derived from the initial findings from the secondary data and the author's experience. The spatial locations and derivation process are shown below as well as emergent thematic pillars.

As the data collection instrument is a written interview, then, as would happen in a face to face interview, considerations and prompts to the responders have been included to aid the flow of the respondents' answers. In the written interview guidance given to respondents, their attention is drawn to a condition that the considerations are guidance only and need not be used in their answers. The influence of researcher bias is a consideration in the use of prompts and considerations.

Considerations are areas that the respondent may wish to discuss in the reply. Respondents are informed in the author's information sheet supplied with the written interview, that these considerations may be ignored in the reply if not required.

**Written Question 1**.
Is the IED removal machinery requirement end user led or manufacturer led? Does the originator (end user or manufacturer) effect the design and capability of the IED removal machinery?

**Considerations.**

- What input do you have into the selection of the machine?
- Do you provide feedback on machine effectiveness to your manager?
- Is the machinery you use modified commercially or bespoke?
- What logistical and support elements should be present to service and maintain the mechanical capability?

**Spatial Location**.
Paragraph 2.2
This shows that the original military demining machines were adapted for use by the mine action community. As mechanical demining has evolved, a similar model can be applied to mechanical IED removal, this can be used to guide and influence the usage of machines and give direction to manufacturers.

**Derivation of the interview question**.
Current experience is to use or modify existing demining equipment for IED removal. The inference from this situation is that no IED removal machinery is available or in commercial production. The design process of IED removal machinery whether it is commercially produced or end user modified, should be understood by the project procurement team so that suitable machinery can be obtained for the specific requirements of IED removal on the project.

**Theme**.
Establish current equipment use.

**Written Question 2**.
Should a test and acceptance protocol, as is carried out on demining machines, be applied to IED removal machines? What, if any, variations from the demining test and acceptance protocol should be considered to the test and acceptance protocol for IED removal machines?

**Considerations**.

- Should IED removal machines be subjected to a detonation test?
- How large would this be?
- Where on the machine should be the point of impact?

**Spatial Location**.
Paragraph 2.3
A test and acceptance protocol for machinery used in IED removal should be developed, in much the same way that demining machinery is tested. This will add to the confidence of operators, the HNMAA and the civilian population

**Derivation of the interview question**.
A test and acceptance protocol in IED removal should act in a similar way to the demining test and acceptance protocol providing confidence to stakeholders. The demining machine and IED removal machine complete different tasks therefore, the test and acceptance protocol should be different and more applicable to each task.

**Theme**.
Establish current equipment use.

**Written Question 3**.
Are on site modifications made to IED removal machines and or IED removal tools? If modifications are made why is this done?

**Considerations**.

- What useful modifications have you seen?
- How were they tested?
- How were they suggested?

**Spatial Location**.
Paragraph 2.4
The IED removal machine should be able to operate without inadvertently activating or destroying IED component parts, in order to complete a render safe procedure.

**Derivation of the interview question**.
Any modifications made should not impact on the test and acceptance protocol or the use of the tool on an IED. The machinery that is available is modified by the IED removal operators, the effectiveness of the original tool then has to be examined for suitability.

**Theme**.
Improvements to existing operations.

**Written Question 4**.
What QA process is required after a machine has completed a render safe procedure?

**Considerations.**

- Are K9's or a search team better suited to carry out QA after an RSP, after the operator has declared safe?
- Could you use another machine?

**Spatial Location**.
Paragraph 2.4
The IED removal machine should be able to operate without inadvertently activating or destroying IED component parts, in order to complete a render safe procedure.

**Derivation of the interview question**.
The QA process should establish the IED as safe and the suspected hazardous area as clear. That process can also allow the safe recovery of IED component parts so that further examination of the component parts may be carried out.

**Theme**.
Establish current equipment use.

**Written Question 5**.
Are the author's fundamentals of IED operations Detect, Defeat, Dispose, Divulge, valid?
**Detect** the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties or by searching of the suspected hazardous area (SHA).
**Defeat** the component parts of the IED in a render safe procedure only resorting to blowing in place when no other options are available.
**Dispose** of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.
**Divulge** from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority component parts and reports as required.

**Considerations.**

- Is there a better different way to approach this?
- Is an operational structure needed?
- Are the statements above accurate?

**Spatial Location**.
Paragraph 2.6
Any mechanical IED removal should aim to support the fundamentals of IED operations.

**Derivation of the interview question**.
The provision of an operational framework will assist operations by providing a planning structure. This should ensure that all steps are followed and no unauthorised deviation from procedures should occur.

**Theme**.
Improvements to existing operations.

**Written Question 6**.
If an IED is to be risk assessed for suitability to be removed mechanically, what factors should be taken into consideration?

**Considerations.**

- Is a risk assessment the correct tool?
- What is the NEQ limit for mechanical IED removal?
- When should mechanical IED removal never be considered?

**Spatial Location**.
Paragraph 2.7
IED classification system, a mechanical suitability matrix may be beneficial to formalise the classifications of IEDs and their suitability for removal by mechanical means.

**Derivation of the interview question**.
In the author's experience there is no formal risk assessment process for the mechanical removal of IEDs. The task is deferred to the judgement of the operator. A mechanical suitability matrix would formalise the process giving the operator a consistent framework and approach.

**Theme**.
Improvements to existing operations.

**Written Question 7**.
Is a tasking system for clearance exclusively the remit of a HNMAA? Can and should clearance organizations aim to influence the tasking system for clearance?

**Considerations.**

- Why should clearance organizations give their opinion?
- What advice would you give to HNMAA?
- What flaws in tasking systems have you seen?

**Spatial Location**.
Paragraph 2.10
The tasking system for clearance must be suitable for the theatre of operations, responsive to the threat and risks prevalent, compliant with HNMAA standards and international requirements and engender confidence in its application.

**Derivation of the interview question.**
As IED proliferation becomes more widespread the input of experienced individuals needs to be considered by the HNMAA to obtain the most efficient results for the time, effort and resources expended in clearance operations. This works on the assumption that the HNMAA does not have any organic IED experienced operators.

**Theme**.
Improvements to existing operations.

**Written Question 8**.
What elements should a training programme for Mechanical IED removal contain?

**Considerations.**

- Should training be for technical field managers and team leaders only or include searchers?
- Is there a requirement for a Mechanical technical field manager to supervise and deliver training?
- How long should training be?

**Spatial Location**.
Paragraph 2.11
Machine operator and end user training is an implied action throughout the process of IED removal in the urban environment.

**Derivation of the interview question**.
Training is an important part of operations. A broad opinion of what training would be expected for operators is anticipated. The author's experience is that machine operators, those who physically operate the IED removal machinery and IED operators, those who physically remove IED component parts and complete the render safe procedure, have little knowledge or experience in the conditions of operation for each other's area of specialism.

**Theme**.
Improvements to existing operations.

### 3.14 Pilot Study Feedback

The response to the pilot study was positive with the pilot respondent giving the author additional clarification on technical points and grammatical accuracy, this would enable the main written interview to be more clearly understood by the main study respondents. The pilot respondent returned the completed written interview within five days without any requests for clarification from the author. This gave the author an indication of an achievable time scale for the issue and receipt of the main written interview.

Of the eight questions asked only two questions required amendment for technical and grammatical clarity.

Question 4 was a clarification of procedure and grammatical accuracy that differentiated between a render safe procedure and the process of separating the component parts of an IED. The point of clarification being that separating component parts does not mean that the IED is then completely safe and a residual risk is still present even though the likelihood is significantly reduced.

Question 5 was a longer question that required a more detailed reply and was technical in the amendments required. The Detection phase was expanded on to include Discovery which then became the primary action, in addition to a clarification of procedure. The Divulge phase was replaced with Exploit and Disseminate to more accurately describe the actions.

The pilot responses guided the categorization of responses for coding for the next phase of the research study of analysing the responses to identify thematic pillars. Regardless of what these thematic pillars are, their influence on the research study must be understood. Of the questions asked in the written interview the author identified four main types of response. Confirmatory, explanatory, questioning and disagreeing.

The confirmatory responses were positive and supported the secondary data and derivation of questions from the secondary data.

The explanatory responses were generally positive and added or developed the question derived from the secondary data.

The questioning responses were neutral in their viewpoint but challenged the question derived from the secondary data.

The disagreeing responses were negative and robustly contested the secondary data and derivation of questions from the secondary data.

### 3.15 Ethical Considerations

The wellbeing of the participants in this research study was a significant consideration. The participants in general had taken part in two-year operation to remove explosive remnants of war from a middle eastern country that had been ravaged by civil war.

Part of the process for the construction of the written interview was to minimise any direct questions that may have a negative unintentional impact, while gaining the opinion and experience of the participants.

An information sheet was designed to give the participants information on informed consent discussing personal data, the ability to withdraw from the study and consent to take part in the study.

A university risk assessment was completed to identify any duty of care issues that may be applicable, with advice for participants to seek appropriate guidance if required.

Data management for the author and university was described and the General Data Protection Regulation 2018 was cited as the direction taken for all data issues.

The confidentiality and anonymity of participants was described, with the caveat that the research study supervisor may request access to original data for the purposes of academic rigor.

The security of information supplied by participants was reiterated so that no operationally sensitive training, techniques or procedures will be released into the public domain.

A complaints procedure was highlighted starting with the author for early resolution and only escalating if required.

### 3.16 Research Logistics

There were numerous sections to this research study that needed equal consideration during the initial stages this was to ensure that once a course of action had been embarked on it was able to be successfully completed.

The selection of the research aim and objectives of the study have been discussed in chapter one and the intent of this section is to describe the logistics and planning to support this research aim and objectives.

### 3.17 Research Project Time Management

A time appreciation was conducted of the key milestones, critical dates, personal time constraints and third-party time constraints. A simple Excel spreadsheet with a timeline was produced with colour coded sections to highlight:

- Chapter submission dates.
- Supervisor tutorial dates.
- Requests for participants to take part in the study.
- Pilot study date including response date.
- Main study date including response date.
- Personal time.
- Supervisor availability.
- Authors expected submission date.
- Actual dissertation submission date.

As the days and key milestones were passed the sections were turned green, this gave a succinct visual map of the progress of the research study. From the confirmation of the research aim to final submission date was 18 weeks. With scheduled personal time this gave a writing pace of 1000 words per week. While this was not set in stone it gave a good indication of expected progress.

Periods of concurrent activity were identified to maximise the use of time. For example. The period of time waiting for participants to respond to the written interview was used to review the author’s dissertation so far and to format and check the appendices.

### 3.18 Participants

While the timeline provided the basic framework for the research study to progress, the key factor in the whole of the research study was securing sufficient participants to ensure that the primary data collected would of a suitable quality to add academic value to the research study.

As part of the process of selecting the research aim a group of potential participants was contacted to gauge their appetite for taking part in an academic study. With their initial response being positive then progress could continue with the reminder of the research study.

The respondents roles and operational experience are pertinent to the research study and are briefly described in the transcript of written interview answers in Appendix 8.

### 3.19 Unforeseen Events

Inevitably conditions change and contingency plans were made to allow for additional time and planning for when these conditions do change.

Within the time appreciation was a two-week period between the author's expected completion to actual dissertation submission date in order to allow for illness, additional personal time or to allow for key milestones not being completed.

The number of participants required for the research study advised by the university was increased by 25% in order to allow for non-participation of the respondents for whatever reason.

### 3.20 Summary

This chapter has set out and explained the methodology used in this research study that will be used in chapter four when the primary data will be collected, analysed and synthesised into the research study conclusions and recommendations.

# CHAPTER 4: Primary Source Findings

## 4.1 Introduction

This chapter will examine the responses of the written interview sent out to the participants and will address research objectives 7 and 8.

7. Gain operational opinion from current practitioners of mechanical IED removal in the urban environment.
8. Analyse primary data and secondary data in association, in order to facilitate the synthesis of conclusions from this analysis.

The responses will be classified into thematic pillars building on the already emerging themes that have emerged from the interim findings of the literature review which formed the basis of the questions asked in the written interview. These thematic pillars will form the foundation for the results and conclusions that will be described in chapter five.

## 4.2 Written Interview Results

The sequence of the questions is designed to follow a natural evolution through from the selection of IED removal machinery, the acceptance protocol, modification, QA process, operational fundamentals, mechanical IED removal risk assessment and tasking and training. This is to attempt to aid the respondents in their replies and follow a logical sequence.

## 4.3 Respondent Profiles

To set context for the participant responses their generic roles and job descriptions are very briefly explained below.

Senior Operations Manager. Responsible for the tasking of clearance teams, prediction of operational requirements including personnel and equipment. Detailed reporting to programme management.

Logistics Manager. Responsible for the procurement of all programme materiel and management of supply chain.

Fleet Manager. Responsible for the scheduled maintenance and inspection of the whole vehicle fleet including the IED removal machinery.

Mechanical Supervisor. Subordinate to the Fleet Manager, responsible for the daily deployment, operation and maintenance of the IED removal machinery and the training of personnel involved in mechanical IED removal.

Safety and Quality Manager. Independent from the operational chain of command, responsible for the safety and quality receipt of programme materiel including the acceptance of IED removal machinery.

Technical Field Manager. Responsible for the daily deployment and management of clearance teams and the selection of assets for tasks, including IED removal machinery. Where qualified the Technical Field Manager will conduct the render safe procedure on IED.

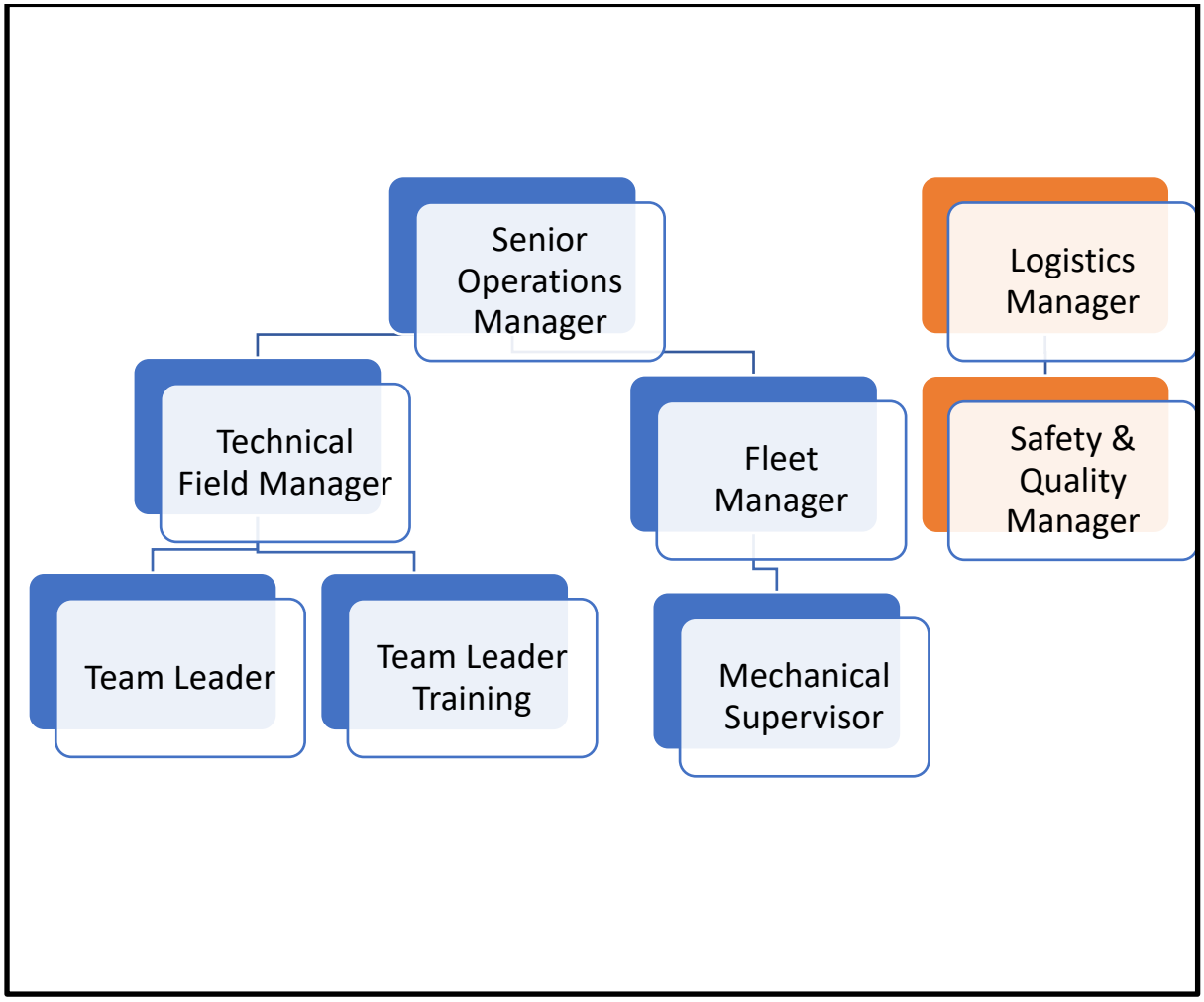
Team Leader. Responsible for the daily supervision of a clearance team including mechanical IED removal. Where qualified the Team Leader will act as the number two for the Technical Field Manager during a render safe procedure on an IED.

Team Leader Training. Responsible for the induction training, continuation training and specialist training of operational personnel. Must be qualified to at least Team Leader level.

To aid in clarity a basic generic organizational chart and job role have been described below, even though the interviewees are from different organizations, this chart will show where the respondent sits generically in their own organization and is shown in Fig 2 below.

The basic generic organizational chart shown below is of a simplified IED removal organization and shows the hierarchical relationships in the operations department and the separation of logistics and Safety/Quality. These functions are separated from operations to allow independent management of the safety and quality control processes but remain part of the whole IED removal organization.

**Fig 2. Basic Generic Organizational Chart of an IED removal organization.**



### 4.4 Thematic Pillars

The responses of the participants were analysed by the author and key words and phrases were identified as being significant in the author's analysis based on:

- The author's operational experiential knowledge as being relevant either by occurrence or by description of an activity.
- The frequency in which the respondents used the key words and phrases.

These key words and phrases were then collated and as these key words and phrases increased in frequency, they were grouped by association into what were to become thematic pillars.

Where there has been a crossover of key words and phrases the author has used operational experience and judgement to allocate the key words or phrases to a thematic pillar. These thematic pillars are based on groups of questions or single questions to aid in focusing the analysis.

### 4.5 Focused Framework Topics

Using the author's experiential knowledge, these key words and phrases were synthesized by the author and focused into framework topics which concentrated the key words and phrases into descriptive activities that could be developed into best practice guidance to clearance organizations.

### 4.6 Cross Referencing

These focused topics were cross referenced with statements made in the written interview transcripts within the parameters of specific questions, to analyse whether the focused topics were answered in an affirmative, explanatory, questioning or challenging manner. This would support, question or challenge the analysis. Question five in the written interview included, the author's fundamentals of IED operations namely Discover, Detect, Defeat, Dispose, Exploit and Disseminate to allow peer review by operational practitioners of their applicability to mechanical IED removal in the urban environment.

### 4.7 Interpretive Outcomes of Primary Data Analysis

The author has arrived at an interpretation of the respondent's answers to the written interview questions by comparing the responses to the original question and the authors experiential knowledge.

#### 4.7.1 Question 1

Is the IED removal machinery requirement end user led or manufacturer led? Does the originator (end user or manufacturer) affect the design and capability of the IED removal machinery?

This question was asked so that the author could understand the relationship between the manufacturer, project management personnel and operators of the mechanical IED removal equipment.

**Interpretation**

There were a range of answers from respondents depending on where they were positioned with the organization and their experience of mechanical IED removal operations. In general at the managerial level respondents had input into the selection of mechanical IED removal equipment, whereas at the supervisory or operator level the respondents had greater input in to the modification of IED removal equipment, in particular the development of specialist tools required for specific tasks.

**Outcome**

The basic capability of the IED removal machine is selected at project level and the detailed task requirements are identified at operator level. One benefit of this outcome is that time, money and resources will be better utilised in the selection and modification to local conditions of IED removal equipment.

A good example of the outcome above is in the response of BL, line 523 and 524 …*again local conditions need to be factored in before machine/tool selection.*

#### 4.7.2 Question 2

Should a test and acceptance protocol, as is carried out on demining machines, be applied to IED removal machines? What, if any, variations should be considered to the test and acceptance protocol for IED removal machines?

This question was asked because there is fundamental difference in the way that landmine removal machines and IED removal machines operate. The author wanted to establish if a test and acceptance protocol was appropriate and practical to create.

**Interpretation**

Across the spectrum of respondent's, the vast majority agreed that a test and acceptance protocol is necessary although there was a mix of opinion on how this could be practically achieved. One factor for consideration is the sacrificial nature of testing IED removal machinery. Tooling was considered to be sacrificial and a test detonation at the point of interface between tool and device was broadly offered as a practical test. A test detonation close to the vehicle operator was considered to be less practical. The net explosive quantity of explosive to be used in the test and acceptance protocol was also a factor for consideration that was unresolved.

**Outcome**

A test and acceptance protocol at local level for tooling is a start point for what is expected by the author to be a long and challenging process before an industry recognised test and acceptance protocol is agreed. Existing engineering data is currently the best available guide to the protection of the machine operator in the event of a detonation. Accident reports from field detonations will also provide data for study by the industry to gain insight for use in the test and acceptance protocol.

This is a start point to begin industry discussion and can form the basis for best practice guidance until such a test and acceptance protocol has been introduced by the industry.

### 4.7.3 Question 3

Are on site modifications made to IED removal machines and or IED removal tools? If modifications are made why is this done?

This question was asked so that the author could understand the mechanism by which any modifications are made, this in turn would lead to an understanding of any formal process requirements.

**Interpretation**

The main reasons for modification are threats, tasks and environment. It is not practical for a manufacturer or supplier to anticipate every scenario that the operator is going to encounter and provide the exact tool or modification to suit the situation. While feedback to the manufacturer or supplier is desirable it is not necessarily commercially viable to make all or any of the modifications described or suggested by the operators. Where modifications are made then a formal process needs to be established in order to manage the changes required.

**Outcome**

Within the best practice guidance, a justification rationale should be outlined so that any operational changes can considered fully and all or any consequences identified. Modifications should not only be approved within the organization but where a test and

acceptance protocol has been used to bring the machine into service, there needs to be a referral to the official body that carried out the test and acceptance protocol.

### 4.7.4 Question 4.

What QA process is required after a machine has completed a render safe procedure?
This question was asked for the author to understand the conditions and constraints of carrying out quality assurance (QA) in the urban environment.

**Interpretation**

The QA process while in itself is a relatively simple process the techniques used to employ the tools used to conduct the QA process are less straight forward. The three basic tools of K9 detection, human search and mechanical shifting all have their place. The knowledge and experience of the individual clearing the site is the key to using the correct technique and tool.

**Outcome**

The best practice guidance provides a practical solution which is to state that the QA process must be practiced in all phases of the operation. The employment of different techniques and the advantages and disadvantages of the different tools available to the operator have to be matched to the conditions on the ground and it is impractical to attempt to formulate a rigid QA process post mechanical IED removal.

### 4.7.5 Question 5

Are the author's fundamentals of IED operations Discover, Detect, Defeat, Dispose, Exploit and Disseminate valid (explanation of the fundamentals provided below).
Discover the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties.
Detect by planned and controlled searching of the suspected hazardous area (SHA).
Defeat the component parts of the IED by blowing in place or using a render safe procedure.
Dispose of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.
Exploit and Disseminate from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority, mine action community and authorities component parts and reports as required.
This question was asked by the author to establish from the respondents if the fundamental phases of IED removal operations were valid. This set of fundamentals was intended to be the basis for an operational framework from which focused topics could be underpinned.

These fundamentals should be applicable to both the rural and urban environment, the latter being the author's focus.

**Interpretation**

The consensus from the respondents was that the author's fundamentals were valid. There were additions that individuals suggested but no variations to fundamental headings. This confirmed to the author that the basic framework of operations was an appropriate model from which a focused framework could be developed.

**Outcome**

Question 5 provided the realization of the research aim to develop best practice guidance. This confirmed to the author that the fundamentals are valid, applicable and practical. There is scope for additional depth and understanding with each fundamental statement but the foundational basis on which the framework of operations is based is academically and experientially sound.

### 4.7.6 Question 6

If an IED is to be risk assessed for suitability to be removed mechanically, what factors should be taken into consideration?

This question was asked for the author to construct a set of conditions that would assist operational teams in achieving consistency when assessing the suitability of IEDs for mechanical removal in the urban environment.

**Interpretation**

The responses highlighted a difference in use of terminology when referring to risk assessments and threat assessments, using the words threat and risk interchangeably. There was also a variation in the documentation for the process of conducting a risk assessment for IED removal in the urban environment. There was an acceptance that the individual operator was best placed to carry out an, on the ground risk assessment, using experience and best judgement with a more formal risk assessment being carried out at the planning stage. Though no structure for conducting a risk assessment was offered by any respondents.

**Outcome**

As part of the best practice guidance a structured risk assessment has been produced for guidance both at the planning stage and for use while operators are making an, on the ground risk assessment. This risk assessment does not use a specific format but takes the form of a list of questions that can be amended as required.

### 4.7.7 Question 7

Is a tasking system for clearance exclusively the remit of a HNMAA? Can and should clearance organizations aim to influence the tasking system for clearance?

This question was asked by the author to establish any variances in home nation mine action authority (HNMAA) systems that respondents have experienced and to identify opportunities for improvement. It also seeks to identify what advice and guidance could be given from a clearance organization to a HNMAA that is being newly formed or has no experience in a particular discipline.

**Interpretation**

The majority of respondents describe tasking systems within HNMAAs as overly bureaucratic, lacking transparency and being difficult to deal with. Poor communication plays a part in this from both sides of the relationship. There is no doubt that HNMAAs are subject to socio-political influences both internally and externally and that clearance organizations are subject to financial pressures internally and externally. These are management issues and should not obstruct the main effort of clearing land and returning it to use.

**Outcome**

A set of principles described in the best practice guidance, presented in the final chapter provides a starting point from which clearance organizations can open dialogue with the HNMAA so that both sides can understand the influences and constraints that each organizations can have exerted on them from outside actors.

### 4.7.8 Question 8

What elements should a training programme for Mechanical IED removal contain?

This question was asked by the author as an implied action, training is a safety and operational requirement for the competent operation of mechanical equipment and understanding by managers and supervisors of capabilities and constraints of the equipment.

**Interpretation**

It became apparent that the scope and depth of information received in responses could not be sufficiently dealt with within the scope of this research study.

**Outcome**

The subject of training for operators, supervisors and managers in mechanical IED removal in the urban environment is beyond the scope of this research study and has been identified as an area for future research.

### 4.8 Conclusion

Chapter four has presented the interpretative outcomes from the primary data provided by the participants of the written interview and analysed by the author. The author has analysed and synthesized these responses into knowledge that can be further developed into best practice guidance, as stated in the aim of this research study. This best practice guidance will be used for mechanical IED removal in the urban environment leading to a greater understanding for the safe and efficient conduct of operations. This best practice guidance will be presented in chapter 5.

# CHAPTER 5: Conclusions and Recommendations

## 5.1 Introduction

This chapter will present the results of the analysis and synthesis completed in chapter four and the conclusions and recommendations based on this.

This final chapter contains the essential elements of the best practice guidance associated with the key thematic pillars. Outside the scope of this research will be the production of training material to be presented to project staff for subsequent use in the future development of capability in IED removal in the urban environment.

The author's approach to the analysis of the primary and secondary data was to identify the frequency of usage and descriptive use of key words and key phrases which were, in the experiential knowledge of the author, considered significant. These words and key phrases were grouped under thematic pillars and the author's interpretation of these answers became the conclusive outcomes of the research.

The research aim and all research objectives are listed below to remind the reader as to the entirety of the process thus far.

## 5.2 Research Aim and Objectives

The aim of this research is to examine the operation of mechanical assets for Improvised Explosive Device removal in the urban environment, in order to identify best practice guidance.

The objectives of this research are:

Chapter 2 Literature Review:

1. Review a brief history of demining machines giving context of development and leading to an understanding of current employment of this equipment.
2. Examine the current operation of mechanical demining machines.
3. Examine future developments and integration of current technology.
4. Define the urban environment.

Chapter 3 Methodology:

5. Using appropriate techniques identify and select a data subject population and sample a representative selection.
6. Employ an interpretive, qualitative model of research to build a persuasive body of evidence to support the achievement of the aim of the research.

Chapter 4 Primary Source Findings:

7. Gain operational opinion from current practitioners of IED removal in the urban environment.
8. Analyse primary data and secondary data in association, in order to facilitate the synthesis of conclusions from this analysis.

Chapter 5 Conclusions and Recommendations:

9. Suggest a method of operation for mechanical assets.
10. Explain the need for this method of operation.
11. Suggest methods for the integration of technological advances.
12. Discuss logistical support and considerations for mechanical assets.

### 5.3 Results

The results of the written interviews are the evidence of the operational opinion and experience of current practitioners. These results demonstrate the identification of focused topics. Additionally, these results support the agreed operational framework of mechanical IED removal in the urban environment. These focused topics being in no ranked order:

1. Financial considerations
2. Operational support
3. Machinery modification
4. Testing and acceptance
5. Mechanical IED removal training
6. Tasking procedure
7. Safe working practices

Question 6 asked what elements of training should Mechanical IED removal contain. As primary data was analysed it became the author's opinion that training is such a significant discipline bringing together a number of differing participants, elements and subjects and is better dealt with in a separate research study and is not in the scope of this research study. The participants are listed below for completeness of results.

1. Searchers,
1. IED removal machine operators,
2. Technical field managers, team leaders and
3. Operations managers.

The authors operational framework for mechanical IED removal in the urban environment is as follows:

1. Discover,
2. Detect,
3. Defeat,
4. Dispose,
5. Exploit and disseminate.

These have been validated by current operational practitioners in the responses to question 5 of the written interviews and will form the basis of the best practice guidance.

### 5.4 Conclusions

The aim of this research study being to identify best practice guidance is realised in the presentation of this guidance in paragraph 5.6 below.

One particular focused topic that emerged from the primary and secondary data was Safe Working Practices. While part of the best guidance practice, the detail of the risk assessment guidance check list is described in Appendix 9.

## 5.5 Recommendations

### 5.5.1 Risk Assessment

Before an operation to mechanically remove an IED in the urban environment can be considered, a risk assessment must be conducted to ensure that this method of removal is the safest and most practicable method of available. In what can be an intense and challenging environment this risk assessment guidance can used and developed by project personnel to ensure that a consistent approach to mechanical IED removal is maintained across the project.

The primary data showing the emergence of safe working practices as a focused topic is in the participant responses to questions 4 and 6 is the evidential cross reference to support the recommendation for a risk assessment.

The participants' responses to question 4 were interpreted as that the methods of quality assurance are best selected by the clearance technical field manager (site clearance team manager) using experiential knowledge, resources available and the suitability of the method for the task. The participants' responses to question 6 were interpreted as that there is a difference in terminology used to describe the risk assessment and there is no structured format.

The interim findings from the secondary data in paragraph 2.12, point 6 is the evidential cross reference to support the recommendation for a risk assessment.

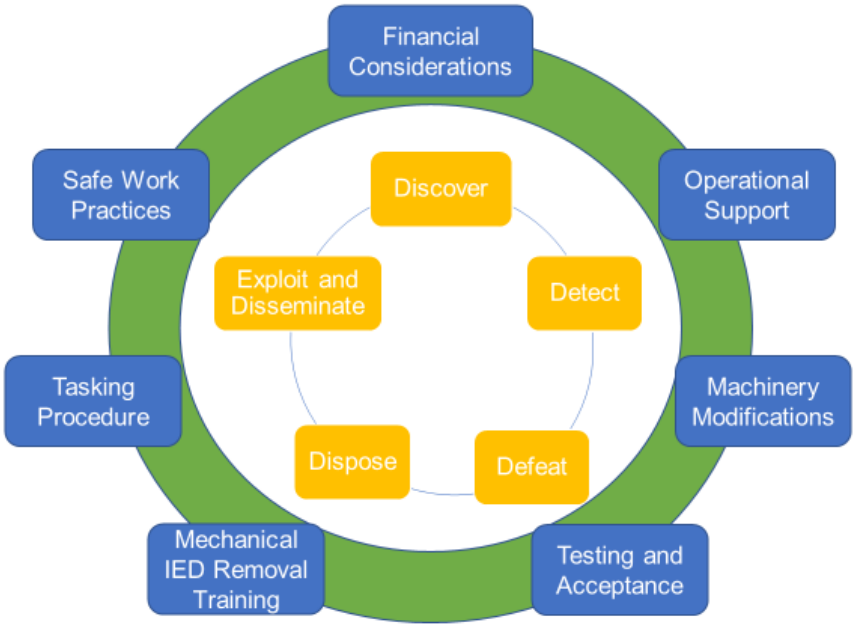
### 5.5.2 Best Practice Guidance

In order for an operation to mechanically remove IEDs in the urban environment to be undertaken, an operational framework has been developed by the author based on the review of secondary data and the analysis of primary data and then by a process of synthesis of the secondary data, primary data and the author's experiential knowledge to ensure that a consistent and logically understandable approach can be used by project personnel.

This operational framework is reinforced by the identified focused topics that can be developed to consider the project whole of life employment of mechanical IED removal machines when operated in the urban environment. This relationship is shown pictorially in Fig 3 below.

This best practice guidance can be used to aid in the development of location specific standard operating procedures, that are based on academically researched industry material and experienced operational opinion from subject matter experts.

**Fig 3. Best Practice Guidance Framework.**



### 5.6 Framework of Operations

The framework of operations should follow the phases below:

- Discover the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties.
- Detect by planned and controlled searching of the suspected hazardous area (SHA).
- Defeat the component parts of the IED by blowing in place or using a render safe procedure.
- Dispose of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.
- Exploit and Disseminate from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority, mine action community and authorities component parts and reports as required.

The primary data in question 5 uses the responses to slightly amend and validate the author's suggested non-military elements.

The military framework comprises of three phases as opposed to the five phases of the best practice guidance. These are Prepare the force, Defeat the device, Attack the network. There are broad similarities in military defeat the device phase and the whole of the best practice guidance.

Under prepare the force, training and lessons learned are elements where as in a commercial IED removal organization these would be functions of the safety and quality assurance departments.

The military have a phase to attack the network, this can involve military intelligence assets and the use of lethal force. There is no legal framework or requirement for these actions in a commercial IED removal organization.

The secondary data in paragraph 2.6 discusses the basic military elements of IED operations and the non-military elements suggested by the author are proposed.

### 5.6.1 Framework Focused Topics

Focused topics were developed by the author from the thematic pillars that emerged as part of the author's analysis of the primary data. These focused topics supported the framework of operations that evolved from the secondary data review.

These focused topics are the basic support framework and may be viewed differently in different operational environments, so may be added to, subtracted from or changed to suit the specific needs of the specific operating environment.

The framework of Focused Topics should include the topics below:

### 5.6.2 Financial Considerations.

a. Donor contract requirements must be considered when procuring IED removal machinery.
b. The procurement process should include consideration of the whole of life employment of IED removal equipment.
c. The operating costs of IED removal equipment should be considered as part of the project financial risk assessment.
d. Changing budgetary constraints should be considered in the procurement process.

The primary data questions 1 and 3 gives responses that discussed the costs of IED removal in the urban environment costs. The secondary data in paragraph 2.2 and table 1 showed a cost comparison model.

### 5.6.3 Operational Support.

a. Maintenance support for IED removal machines should be a pre-requisite of mechanical IED removal operations.
b. Logistical support to IED removal machines should be considered when project planning.
c. Technical support from manufacturers should be encouraged to support clearance organizations deployed on operations.
d. A Mechanical Technical Field Manager should be considered as a key role to mechanical IED removal operations.
e. Operational Record Keeping is fundamental to the efficient maintenance and servicing of IED removal equipment.

The primary data questions 1, 3 and 4 gives responses that discussed operational support issues. The secondary data in paragraphs 2.2 and 2.8 discusses operational support issues.

**5.6.4 Machinery Modification.**

a. Modification of IED removal machinery for tools and protection may be required to suit the need of organization.
b. End user input into modifications and manufacturer design is desirable.
c. Experience proven modifications to IED removal machinery and tools can add to local capability.
d. Increased capability of IED removal machinery is a desired outcome.
e. All modifications should be sanctioned, tested and approved IED removal machinery completed by an established test and acceptance protocol.

The primary data in questions 1 and 3 gave responses that discussed machinery modification. The secondary data in paragraphs 2.4 and 2.8 discuss machinery modification.

**5.6.5 Testing and Acceptance.**

a. Pre-inspection of IED removal equipment, modifications and tools is required for quality control and suitability.
b. Survivability of personnel is paramount, survivability of IED removal machinery and tools is desirable.
c. IED removal machinery should be tested and assessed against known net explosive quantities.
d. Data collection from an established test and acceptance protocol should be widely disseminated within the industry.

The primary data in question 2 gives responses to a testing and acceptance protocol. The secondary data in paragraph 2.3 discusses a test and acceptance protocol.

**5.6.6 Mechanical IED Removal Training.**

a. Training must be certified as being delivered by a competent person or organization.
b. All operational personnel must be qualified to perform their role.
c. All operational personnel should be experienced to perform their role.
d. All training must be compliant with standard operational procedures and international standards.

e. A practical assessment of all operational personnel must be included as part of the training programme.

The primary data in question 8 gives responses to training issues. The secondary data in paragraph 2.11 discusses training as an implied action and acknowledges that this requirement is beyond the scope of this research study.

**5.6.7 Tasking Procedure.**

a. Intelligence led tasking from the home nation mine action authority is required by clearance organizations.
b. Good command and control exhibited by the tasking organization improves the clearance process.
c. A simple system for collation of information and tasking of clearance teams is required by clearance organizations.
d. Tasking organizations are encouraged to clearly define critical infrastructure and humanitarian infrastructure requirements.
e. Tasking organizations are encouraged to use trained personnel for the process of collation and tasking clearance teams.

The primary data in question 7 gives responses to the tasking procedure. The secondary data in paragraph 2.10 discusses the tasking procedure.

**5.6.8 Safe Working Practices.**

a. Risk assessments must be carried out for all operations.
b. Threat assessments must be carried out on all tasks.
c. Standard operating procedures must be developed and practiced.
d. Safe working practices must be employed in all phases of operations.
e. Quality control must be carried out on all phases of the operation.

The primary data in questions 4 and 6 gives responses to safe working practices. The secondary data in paragraph 2.7 discusses the safe removal of IEDs.

### 5.7 Concluding Remarks

The author's initially conceived thoughts on operational fundamentals for the operation of IED removal in the urban environment were supported by the secondary data and confirmed by the primary data. These operational fundamentals were developed into a framework of operations as described above which give consistency, progression, logical conclusion and structure to the process of IED removal in the urban environment.

From the primary data a framework of Focused Topics was developed which formed the basis of the best practice guidance that was the aim of this research project. This guidance will allow for personnel to consider a range of issues that may not have been immediately apparent at the outset of the planning phase, this guidance can be amended, added to or subtracted from as required.

The concept and origin of the risk assessment in Appendix 9 is generated from primary and secondary data, the detailed steps as described in appendix 9 are derived from the author's experiential knowledge and are a start point for future use on IED removal operations.

### 5.8 Validation of The Author's Work by His Technical Peer Community

The author's employers have read the author's dissertation and been in detailed discussion with him as to how best to utilize the best practice guidance developed in this research study for use in the current standard operating procedures used by the company in Syria. This is in order to further the development the practical aspects of mechanical IED removal in the urban environment. The author's employer is a member of the International Mine Action Standards review board who provide advice and guidance to the United Nations Inter-Agency Coordination Group on Mine Action. Consequently it is likely that the author's research output may feed into the work and outputs of the Review Board.

Additionally, James Madison University have requested a copy of the author's dissertation. This is for inclusion into the Global Conventional Weapons Destruction Repository, this repository is managed by James Madison Universities Center for International Stabilization and Recovery and is intended to be a global database for research and data resources. James Madison University also sits on the International Mine Action Standards review board. Thus the validity of the author's research output has been recognised by organisations in the global technical peer community active in this field.

### 5.9 Reflective Practitioner

The research study has been a positive and successful undertaking which has achieved the intended research aim and research objectives. As part of a holistic approach to lifelong learning the author has the following reflections on the research study.

Effective preparation for the research study creates the conditions for potential success, it does not guarantee success, part of this effective preparation was the selection of the research topic. Throughout the preparatory dissertation lectures the emphasis on topic selection and use of the aim selection criteria were an effective model and tool for the author.

The concept of research logistics was new to the author but transferable knowledge from a previous military life summarised as: Prior planning and preparation prevents poor performance, provided a foundation to base the research logistics concept upon. A key action here was to informally approach potential participants for the research to gauge their availability and willingness to take part in an academic research study. This action had to tie into the selection of a research topic. One of the first questions nearly all potential participants asked was, “What is it about?”, the author was aware that potential participants should be comfortable with the research topic or there was a risk they would not wish to participate.

Time management was also a key action in the research logistics process. A time appreciation working back from the submission date was conducted, significant events were diarised, with milestones and deadlines identified. While this was a living document with minor amendments being made, it was a crucial visual check to the author’s progress.

Using established work habits was a considerable aid to the whole process of completing the research study. The practice of working office hours (9 to 5) was adopted by the author, having weekends off and brain storming on wipe boards were additional habits that the author found beneficial. Additionally, being prepared for supervisor’s meetings by setting agendas and submitting minutes of meetings held aided the habitual normality.

The author was surprised at the sheer volume of words from the responses that had to be written up for the transcript appendix. An effective methodology for analysis needs to be employed in order to remain organized and effective in the collation and analysis of results. After working so hard to collect data, it was difficult not to include everything in chapter four.

However, this is part of the analysis process and must be accepted. The data is not lost it is available in an appendix.

The value of the pilot study cannot be overstated. However, it is only one set of answers from potentially many, so the responses must be tempered with the need for pertinent changes against wholesale change that may affect the purpose of the pilot study.

The main study must be managed. The author encouraged respondents during submission, being careful not to intrude on personal time, especially after self-imposed deadlines had passed. All replies, even partial replies are valuable, it was obvious that some respondents felt that some questions were outside of their sphere of understanding. However, in other areas they were extremely knowledgeable. This must be accepted if you are looking for a broad spectrum of replies. A limitation of the main study could be that no IED removal machine operators were involved in the main study, this was due to language comprehension issues. This was mitigated by a mechanical supervisor being involved in the main study.

One issue that re-emerged which had been experienced by the author previously in different industries is an assumed level of knowledge (by the author) of personnel. These potential knowledge gaps in project personnel will become a consideration for the author when returning to a project and how best to address these potential knowledge gaps.

### 5.10 Further Study

There are a number of fields of further research that could be explored at a later time, specifically of interest to the author are:

The variations between mechanical IED removal in the urban environment and mechanical IED removal in the rural environment.

Identifying the core training competencies required for a comprehensive mechanical IED removal training programme.

Devising a suitable test and acceptance protocol for IED removal machinery.

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## APPENDIX 1 - AIM SELECTION CRITERIA

The selection criteria used to select the aim of this study were:

- Relevance.
- Achievability.
- Personal benefit.
- Unambiguity.

### (1.1) Relevance

The demining industry is experiencing an increase in the proliferation of IED's within the urban operational environment. The past tactic of using mechanical assets to more safely and quickly remove land mines is a logical transfer of training, techniques and procedures (TTP's). However, due to the difference in operation and function of the ordnance there is a requirement to change the past demining operating methods to a more appropriate IED removal methodology.

### (1.2) Achievability

In practical terms some of the constituent phases of mechanical IED removal are available to operators, but there is still the requirement to synthesise these separate phases into a holistic, effective system. With the consideration that additional TTP's can bring extra dimensions to the understanding of the process.

### (1.3) Personal Benefit

The author is currently working in this field of endeavour and through tragic personal experience, has identified the need for the production of best practice guidance to better safeguard the operators and the civilian population. So that these operations provide the much-needed humanitarian relief for are intended for.

### (1.4) Unambiguous

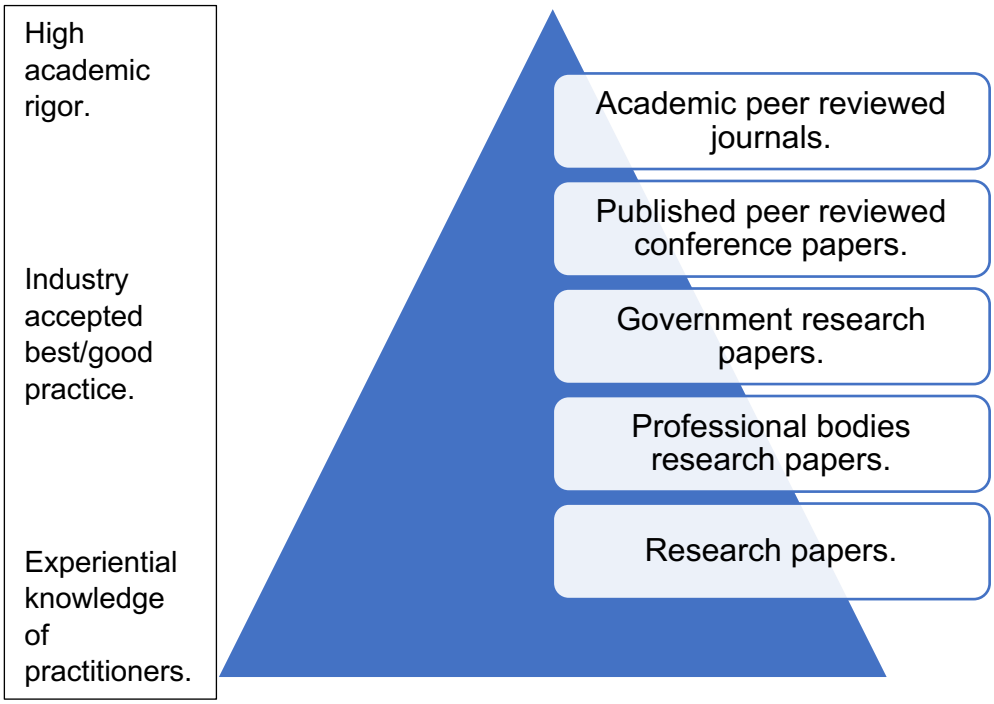
The end result of this research study will be the production of best practice guidance that will be employable globally, with the ability to tailor the requirements to local conditions against a framework that has been researched, validated and applied practically in other operational environments.

## APPENDIX 2 - HIERARCHY OF RESEARCH

### (2.1) Introduction

In order to create a framework to classify resources a hierarchy of research has been structured as shown below in Fig 4. This has been done to demonstrate the differing levels of academic rigor that have been applied to the varying levels, so that the context can be understood in consideration as research material.

**Fig 4. Hierarchy of Research.**




### (2.2) List of Resources Examined During Literature Review.

The following is a list of resources that were used by the author in the research for this study.

1. 2002 Mechanical Mine Clearance Technologies.
2. Adapting the ERW Community to Combat IED Threats.
3. Counter-IED Report Spring-Summer 2018.
4. Demining 2010. A Challenge to the Demining Community.
5. GCIHD MechDem-Handbook-2009.
6. How Iraq is Changing What We Do.
7. Humanitarian Demining. The Challenge for Robotic Research.

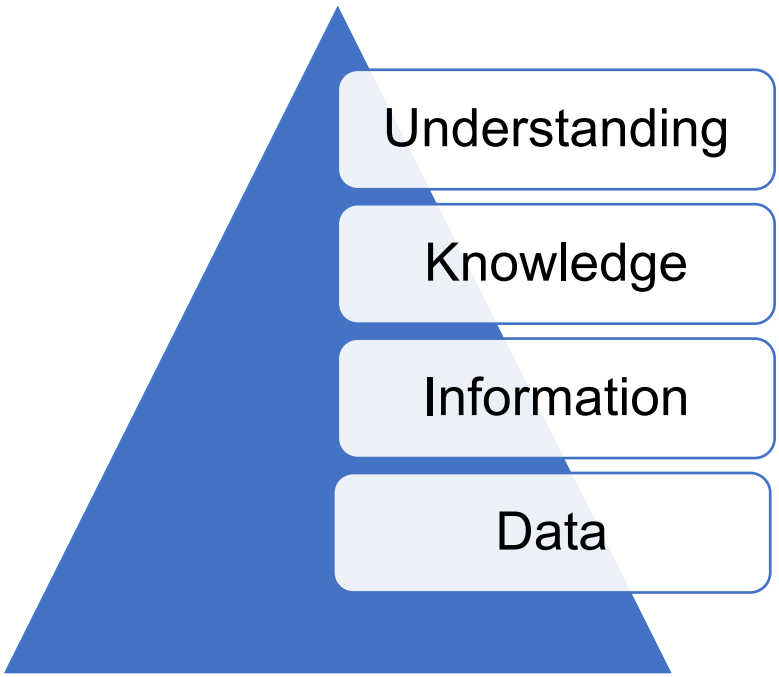
8. IMSMA-Symbology-Final Report.
9. The journal of ERW and mine action.
10. Machines Can Get the Job Done Faster.
11. National Mine Action. Problems and Predictions.
12. Quality Management and Standards for HIED Response Activities.
13. Swedish military Report Crew Safety.
14. Testing and Use of Demining Machines in the Republic of Croatia.
15. The Demining of Farmland.
16. The GICHD Tool for Management of Mechanical Demining Operations.
17. To Walk the Earth in Safety 2019.
18. UN Proliferation of IEDs Report.

This research material is the secondary source for the collection of data, which is processed by analysis, question and synthesis to provide an academic answer to the research questions.

**(2.3) Knowledge Hierarchy**

The origin of the knowledge hierarchy is unclear and therefore impractical to reference accurately. However, the author acknowledges this is not original academic discovery. The knowledge hierarchy is show diagrammatically in figure 5 below.

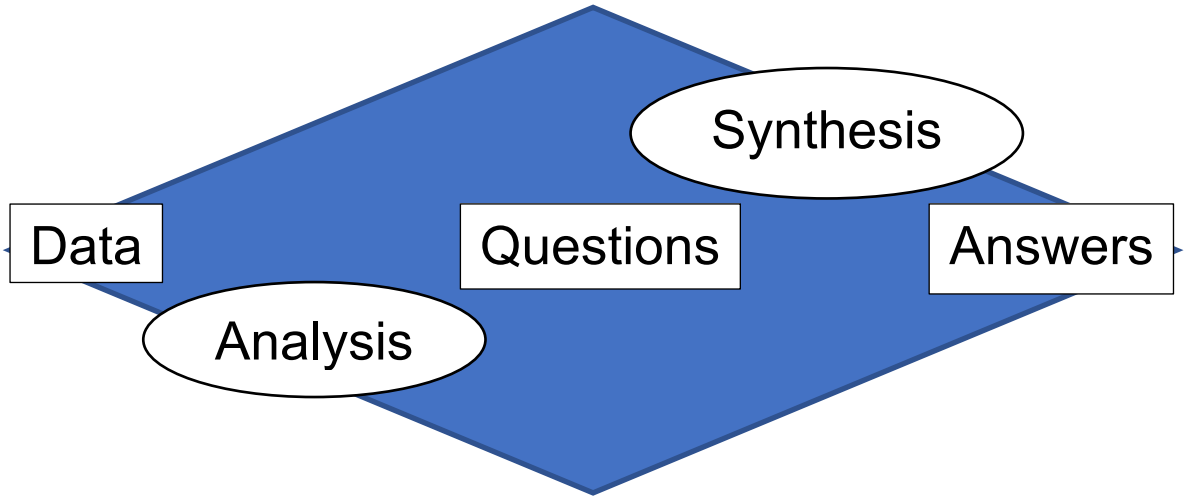
**Fig 5. Knowledge Hierarchy.**



### (2.4) Data Treatment

On the edges of the process of posing the research question, gathering data and answering the question sit the actions of Analysis and Synthesis. While the analysis identifies the component parts of the argument, the synthesis re-combines these component parts into coherent and logical argument. This is expressed diagrammatically below in Fig 6.

**Fig 6. Data Treatment.**

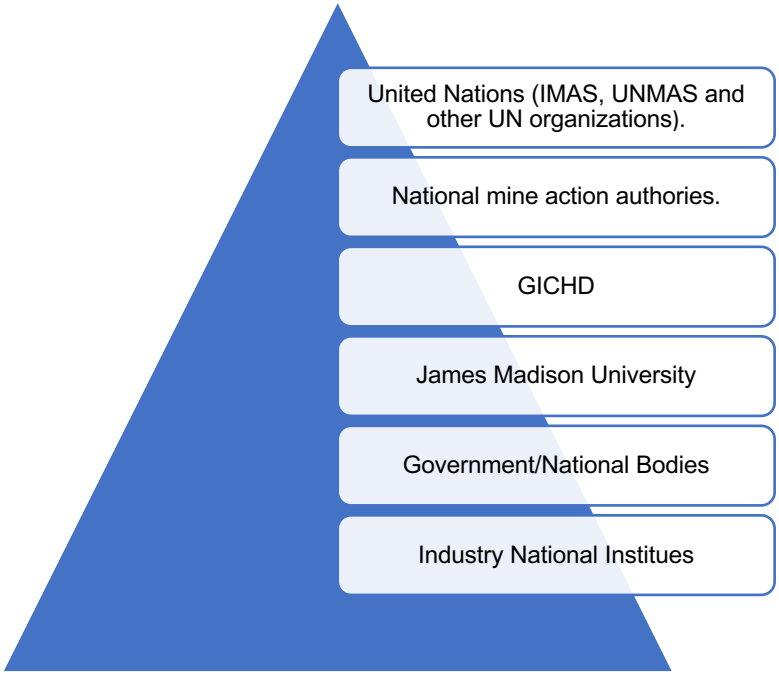


## APPENDIX 3 - HIERARCHY OF SOURCES

### (3.1) Introduction

In order to create a framework to classify resources the hierarchy of sources has been structured as shown below in Fig 7. This has been done to demonstrate the differing levels of understanding and maturity of systems that have been applied to the varying levels, so that the content can be understood in its consideration as research material.

**Fig 7. Hierarchy of Sources.**



## APPENDIX 4 - GLOSSARY OF TERMS

### (4.1) Introduction

In order to clarify technical terminology and operational definitions official IMAS definitions are used where appropriate. Where is there is ambiguity within the industry this is highlighted.

**Mechanical demining**. The term 'mechanical demining operations' refers to the use of demining machines on demining operations and may involve a single demining machine employing one mechanical tool, a single demining machine employing a variety of tools or a number of machines employing a variety of tools. (IMAS 09.50 Page 1).

**Improvised Explosive Device**. The term 'Improvised Explosive Device' (IED) refers to a device placed or fabricated in an improvised manner incorporating explosive material, destructive, lethal, noxious, incendiary, pyrotechnic materials or chemicals designed to destroy, disfigure, distract or harass. They may incorporate military stores but are normally devised from non-military components.[4] (IMAS 09.30 Page 6). An industry additional definition.[5]

**International Mine Action Standards** (IMAS). The United Nations Mine Action Service (UNMAS) endorsed organization for global mine action standards.

**United Nations Mine Action Service** (UNMAS). Works to eliminate the threat posed by mines, explosive remnants of war and improvised explosive devices by coordinating United Nations mine action, leading operational responses at the country level, and supporting the development of standards, policies and norms.

**Training, techniques and procedures** (TTP's). Industry Definition. A skill set particular to the role being conducted that is constantly reviewed and updated to keep pace with the emergent threat.

**Explosive Remnants of War** (ERW). Unexploded Ordnance (UXO) and Abandoned Explosive Ordnance (AXO)

[4] An IED may meet the definition of a mine, booby trap, and/or other type of explosive ordnance depending on its construction. These devices may also be referred to as improvised, artisanal, or locally manufactured mines, booby traps, or other types of explosive ordnance.
[5] Any commercially/factory produced munition that has been altered to function in any other way other than as intended is classed as an IED.

**Suspected Hazardous Area** (SHA). An area where there is reasonable suspicion of explosive ordnance contamination on the basis of indirect evidence of the presence of mines/ERW. (IMAS 04.10 Page 48).

**Confirmed Hazardous Area** (CHA) refers to an area where the presence of explosive ordnance contamination has been confirmed on the basis of direct evidence of the presence of Explosive Ordnance. (IMAS 04.10 Page 9).

**Spot Task**. Where a single item of ERW (mine, ordnance, IED, etc) is neutralised by an approved method.

**Render Safe Procedure** (RSP). An RSP is conducted to permanently neutralise an IED. The end result is that the device is in a safe state and the only action required is the final disposal of any explosive components including main charge(s) and detonator. (IMAS 09.31 Page 12).

**Blown in Place** (BIP). Where an IED is intentionally detonated in situ. Protective works are rarely put in place for BIP of an IED due to the risk of workers.

**Protective works**. Field engineering techniques to limit the effect of an explosion on the surrounding infrastructure.

## APPENDIX 5 - REQUEST FOR PARTICIPATION

Dear Participant

After the informal enquiry in May 2019, please consider this a formal request for participation in a study into **Mechanical IED Removal in The Urban Environment**, in order to support research into an MSc Degree.

The conditions of participation will be under the policies of the University of South Wales which will include:

- Informed consent for participants.
- Duty of care of participants.
- Data management of participants information.
- Confidentiality and anonymity of participants.
- Security of information supplied by participants.
- Complaints procedure.

Ethics, the study will be completed in line with the University of South Wales ethical policy.

Please read through the information below and sign to acknowledge agreement and participation.

Thank you for your time and participation. If you have any further questions please do not hesitate to get in touch with the Author to discuss any issues.

Your co-operation is appreciated.

Regards

David Parry
Student ID 16004760

**Informed Consent**
There is no requirement for personal data to be supplied.
Participants may freely withdraw at anytime and data withdrawn from the study, where practicable. i.e. before submission.
Signed consent to participate is required under university ethical guidance.
Returning the completed document implies consent to participate.

**Duty of care of participants.**
A university risk assessment has been completed to assess any duty care issues with participants and none have been identified. However, if issues arise due to the nature of the written interview, participants are advised and encouraged to seek appropriate guidance a soon as possible.

**Data management of participants information.**
Only the author and in specific circumstances the academic supervisor will have access to raw data.
This data will be password protected while under control of the author.
Research findings will be available to participants by request on successful completion of the project.
Any data held by USW will be in accordance with GDPR 2018.
Any data supplied will only be used for this research project.

**Confidentiality and anonymity of participants.**
All names, appointments, job titles or other identifiable information will not be released in the public domain.
In specific circumstances the academic supervisor of the author can request to view the list of participants in order to ascertain authenticity.

**Security of information supplied by participants.**
All information will be treated as confidential and sensitive.
No operational procedures will be released into the public domain.

**Complaints procedure.**
In the first instance please raise any complaints with the author. If this is deemed inappropriate, please contact the University of South Wales direct for further assistance.

---

I consent to take part in the research project under the conditions described above.

Name_____

Date_____

Signature_____

## APPENDIX 6 - STUDY CONSENT FORM

University of South Wales
Prifysgol De Cymru

**STUDY CONSENT FORM**

Title of Project: **Mechanical IED removal in the urban environment.**

Name of Researcher: **David Howell Parry**

Name of supervisor: **Dr Paul Ryall**

Please **(initial)** all boxes

1. I confirm that I have read and understand the information sheet dated **07 Aug 2019** (**version 1.0**) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without any consequence to myself. ☐

3. I agree to my anonymised data being used in study specific reports and subsequent articles that will appear in academic journals as part of this study. ☐

4. I agree to take part in the above study. ☐

| Name of Participant | Date | Signature |
|---|---|---|
| Name of person - taking consent. | Date | Signature |

## 1. Introduction

Thank you for taking the time to complete this written interview. Initially to answer any questions you may have please read the accompanying request for participation document. If you have any further questions please do not hesitate to get in touch with the author.

## 2.Considerations

As this is a written interview, the considerations paragraph is only intended to act as a prompt to your opinion and experience. If you feel it is unnecessary then please ignore it.

Your opinion and experience are the most important elements of your answers.

## APPENDIX 7 - WRITTEN QUESTIONAIRE

**Question 1.**

| |
|---|
| Is the IED removal machinery requirement end user led or manufacturer led? Does the originator (end user or manufacturer) effect the design and capability of the IED removal machinery?<br><br>**Considerations.**<br>What input do you have into the selection of the machine?<br>Do you provide feedback on machine effectiveness to your manager?<br>Is the machinery you use modified commercial or bespoke?<br>What logistical and support elements should be present to service and maintain the mechanical capability? |
| **Answer** |

**Question 2.**

| |
|---|
| Should a test and acceptance protocol, as is carried out on demining machines, be applied to IED removal machines? What, if any, variations should be considered to the test and acceptance protocol for IED removal machines?<br><br>**Considerations**.<br>Should IED removal machines be subjected to a detonation?<br>How large would this be?<br>Where on the machine should be the point of impact? |
| **Answer** |

**Question 3.**

| |
|---|
| Are on site modifications made to IED removal machines and or IED removal tools? If modifications are made why is this done?<br><br>**Considerations**.<br>• What useful modifications have you seen?<br>• How were they tested?<br>• How were they suggested? |
| **Answer** |

**Question 4**.

| |
|---|
| What QA process is required after a machine has completed a component separation?<br><br>**Considerations.**<br>• Are K9's or a search team better suited to carry out QA after an RSP, after the operator has declared safe?<br>• Could you use another machine? |
| **Answer** |

**Question 5.**

Are the author's fundamentals of IED operations Detect, Defeat, Dispose, Divulge valid?

**Discover** the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties.
**Detect** by planned and controlled searching of the suspected hazardous area (SHA).
**Defeat** the component parts of the IED by blowing in place or using a render safe procedure.
**Dispose** of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.
**Exploit and Disseminate** from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority, mine action community and authorities component parts and reports as required.

**Considerations.**

- Is there a better different way to approach this?
- Is an operational structure needed?
- Are the statements accurate?

**Answer**

**Question 6.**

If an IED is to be risk assessed for suitability to be removed mechanically, what factors should be taken into consideration?

**Considerations.**

- Is a risk assessment the correct tool?
- What is the NEQ limit for mechanical IED removal?
- When should mechanical IED removal never be considered?

**Answer**

**Question 7.**

Is a tasking system for clearance exclusively the remit of a HNMAA? Can and should clearance organizations aim to influence the tasking system for clearance?

**Considerations.**

- Why should clearance organizations give their opinion?
- What advice would you give to HNMAA?
- What flaws in tasking systems have you seen?

**Answer**

**Question 8.**

| |
|---|
| What elements should a training program for Mechanical IED removal contain?<br><br>**Considerations.**<br>• Should training be for TFM's and TL's only or include searchers?<br>• Is there a requirement for a Mechanical TFM to supervise and deliver training?<br>• How long should training be? |
| **Answer** |

## APPENDIX 8 - WRITTEN INTERVIEW TRANSCRIPTS

Affirmative – Explanatory – Questioning – Challenging – Thematic Pillars

**Role**: JC. Senior Operations Manager **Operational Experience**: 20+ years

**Pilot Written Interview Answers**

**Question 1**

Is the IED removal machinery requirement end user led or manufacturer led? Does the originator (end user or manufacturer) effect the design and capability of the IED removal machinery?

Considerations.

What input do you have into the selection of the machine?

Do you provide feedback on machine effectiveness to your manager?

Is the machinery you use modified commercial or bespoke?

What logistical and support elements should be present to service and maintain the mechanical capability?

**Answer**

IED remote removal machinery is for the most part driven by the “end user”, however some companies have taken it upon themselves to hire their own subject matter experts, in an effort to enhance this machines and capabilities. This has improved the quality and capabilities of the machines when purchased off the shelf, with that said it is impossible to foresee all aspects and environment of clearance and produce a machine that can fulfil the role off the shelf.

Depending on the clearance organisations structure and contractual arrangements with manufactures of these machines affects the selection process for the assets. It has been seen to be cost and affiliation driven within the clearance industry. This leads to not always having the right machine for the job. In cases like this there is a lot of “in house modification” to the tools and machines to make them best suit the clearance organisations known threat and environment. With these “in house modification” happening on a regular basis it is essential that the clearance organisation have a fully stocked and manned fabrication workshop located somewhere within the project. There must be a well-managed logistical supply chain in place to facilitate such modifications and maintenance.

**Question 2.**

Should a test and acceptance protocol, as is carried out on demining machines, be applied to IED removal machines? What, if any, variations should be considered to the test and acceptance protocol for IED removal machines?

Considerations.

Should IED removal machines be subjected to a detonation?

How large would this be?

Where on the machine should be the point of impact?

**Answer**

Yes, I believe there should be a “test and acceptance protocol” for such machines as with all demining and clearance tools. It should be an industry standard with guidelines from outside the manufactures control.

Some of the points that should be test are, but not limited too;

- Daily operating costs
- Required daily maintenance hours against operational hours
- Minimum requirements to transport the machine from task to task
- Ease of purchase off the shelf replacement parts and components
- Manufactures hostile environment logistical support abilities
- Manufactures technical support to field mechanics and the availability of this support
- Manufactures ability and willingness to train clearance organisations staff to “train the trainer” levels
- Operational distance of operator remote control, within a steel reinforced concrete structure
- Visibility of operations through machine mounted camera systems
- Operational distance of camera signal from machine within and steel reinforced concrete structure
- The ability to mount ECM on the machine
- Self-recovery with the machine should there be a mechanical failure (i.e., independent electric winch)
- Blast survivability at the manipulator arm tool. (5kg)
- Ability to “up armour” machine with either hard or soft armour

**Question 3.**

Are on site modifications made to IED removal machines and or IED removal tools? If modifications are made why is this done?

Considerations.

- What useful modifications have you seen?
- How were they tested?
- How were they suggested?

**Answer**

Modifications are made to tools and machines by all clearance organisations, this occurs based on the threat faced and the environment of operations. It is not possible to foresee or predict what and how the terrorist/insurgent will manufacture or use IEDs in each country without first-hand experience. The manufactures do their best to do this, but it is a physical

impossibility, hence the modifications. Some manufactures will use this information fed back to them as a start point for R&D.

Some locally manufactured tools are as simple as a rake made to suit the size and dimensions of found IEDs. The addition of cameras to the machine permitting better all-round vision with structures is common. All modifications are based on unknown threat and operational environment.

**Question 4.**

What QA process is required after a machine has completed a render safe procedure?

Considerations.

- Are K9's or a search team better suited to carry out QA after an RSP, after the operator has declared safe?
- Could you use another machine?

**Answer**

The remote machine cannot fully finish an RSP, they do not have the correct manipulation at the tools, for example; to shunt and shield electric detonator wires. The machines remove the risk to life by creating standoff from the IED for both machine operator and IEDD operator during the separation IED components. The RSP is only complete when an IEDD operator has carried out all aspects of RSP and has physically confirmed this him/herself. After the machine has made such separation of components it is possible to use a second machine/tool to observe this before the IEDD operator moves forward to RSP the device, only after observing the appropriated soak time IAW SOPs. This precludes searchers and K9 from going forward as only a current and validated IEDD operator is capable of the RSP.

**Question 5.**

Are the author's fundamentals of IED operations Detect, Defeat, Dispose, Divulge valid?

Detect the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties or by searching of the suspected hazardous area (SHA).

Defeat the component parts of the IED in a render safe procedure only resorting to blowing in place when no other options are available.

Dispose of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.

Divulge from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority component parts and reports as required.

Considerations.

- Is there a better different way to approach this?
- Is an operational structure needed?

- Are the statements accurate?

**Answer**

Fundamentally this listed steps below are accurate by title, however the authors understanding may be a little off. Please see points below.

Detect the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties or by searching of the suspected hazardous area (SHA).

Detect is correct, however the explanation is not entirely accurate. The location and type of IED is right. The gathered information from local population, past reports and third parties will only provide enough information to warrant a SHA. The actual Detect is done by a deliberate, systematic, methodical, planned and controlled search carried out by trained searchers.

Defeat the component parts of the IED in a render safe procedure only resorting to blowing in place when no other options are available.

Defeat the preferred method should be Blow in Place (BIP), this removes the risk to life of the IEDD operator manually or remotely disassembling an IED, however the BIP can only occur once the switches have been found, identified and avoided. The BIP should also only happen if the structure or local surrounding s can sustain an explosive detonation. IF a BIP is not possible then a remote separation of IED components should be attempted, if this is not possible the IEDD operator should use Semi-remote means and only use hands on manual RSP as an absolute last resort.

Dispose of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible. Agreed Divulge from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority component parts and reports as required.

Exploitation and Dissemination If possible all components of the IED should be, but not limited to, examination, tested for functionality, recorded, photographed, finger printed, and reconstructed but to mention a few. This information and picture of the IED maker can then be used to set new TTPs' for clearance organisations, in addition it builds and profile of the IED maker and his/her signature. This information should be shared throughout the HMA community and the authorities that will want to arrest and prosecute the IED makers.

**Question 6.**

If an IED is to be risk assessed for suitability to be removed mechanically, what factors should be taken into consideration?

Considerations.

- Is a risk assessment the correct tool?

- What is the NEQ limit for mechanical IED removal?
- When should mechanical IED removal never be considered?

**Answer**

Once an IED has been detected through a search, it can be assessed for the correct method of disposal, at this time it can be determent is mechanical means are warranted.

Some considerations at this point, but not limited to are;

- Machine accessibility
- Suitable tools for the manipulator arm
- Correct safety distances with remote means
- Lifting capacity against the estimated overall weight of IED once component separation has been achieved.

It should be remembered that all remote machines in the IEDD environment are “sacrificial” tools and are there to reduce or eliminate risk to life.

Machines should not be considered if their presence will have a negative affect on the surroundings and structures and would cause additional unwarranted damage.

**Question 7.**

Is a tasking system for clearance exclusively the remit of a HNMAA? Can and should clearance organizations aim to influence the tasking system for clearance?

Considerations.

- Why should clearance organizations give their opinion?
- What advice would you give to HNMAA?
- What flaws in tasking systems have you seen?

**Answer**

There are many contributing factors to the tasking of clearance sites, HNMAA is definitely one of them as they serve the national interest for the most part. The biggest flaw with HNMAA is that they can be self-serving, wanting sites cleared that should not be prioritised as urgent.

The contracts the clearance organisations have with their clients/donors has a major part in it. Depending on what the client wants to achieve will depend on what sites the clearance organisations will take on. Another factor is the actual clearance capabilities the organisation has. Some sites may be beyond their abilities and should be avoided.

**Question 8.**

What elements should a training program for Mechanical IED removal contain?

Considerations.

- Should training be for TFM’s and TL’s only or include searchers?
- Is there a requirement for a Mechanical TFM to supervise and deliver training?
- How long should training be?

**Answer**

The machines themselves are capable of much more than just IED work, this means that all aspects of their capabilities should be taught to the machine operators. TFMs and TLs should not be trained on the machines unless the clearance organisations SOPs state that the operator must be IEDD qualified, the TFM/TLs have far too many things to be managing on the task site to have to run and maintain a machine.

The machine operators should as a minimum have the following training (in house)

- Basic IED component awareness
- Basic UXO awareness
- Machine operations (minimum 2 weeks training)
- Machine maintenance (daily)
- Clearance organisation SOPs related to machine operations and IEDD/CIED

The machine training should be delivered by either the manufacturer's training team of a qualified trainer that has been certified by the manufacturer. For both operators and mechanics, a like. The EOD training must be delivered by qualified EOD/IED operator.

**Pilot study answers end.**

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**Main study written interview answers, slight change of question for 4 and 5. These questions are repeated with changes underlined to add clarity.**

**Role**: ST. Technical Field Manager **Operational Experience**: 10+ years

**Question 1.**

**Answer**

In my experience as TFM I have had no input on the selection of IED RM.

The main drivers are the procurement timing and restrictions;

The equipment is ordered before the specific requirements are understood (due to necessity).

Restrictions in procurement, location/logistical issues, political issues.

Timing is another element that effects design and capability, can a manufacturer react to a specific projects demands, is this cost effective/practicable (project duration allowed).

**Question 2.**

**Answer**

IED RM should be subject to a quality and performance acceptance process (where practicable) this must be carried out by the end user.

Test and acceptance criteria should be broken down into 2 stages;

1, Function and quality testing, (carried out by procurement process),

2, suitability to task, (carried out by end user).

By their nature this equipment can be very delicate and as such field repair rather than survivability should be the main consideration.

**Question 3.**

**Answer**

For some of the reasons above;

1, extended procurement lines

2, suitability to task

3, field repair

Modifications are necessary.

Modifications fabricated in the field;

1, additional armour

2, cameras

3, rakes

These were suggested by end users.

**Question 4.**

What QA process is required after a machine has completed a component separation?

**Answer**

The (suitably skilled/qualified) person running the task should QA the action carried out by the machine, (the machine operator would NOT declare safe at any stage).

I know of no machine capable of assessing such a process and deciding on the outcome.

**Question 5.**

Are the author's fundamentals of IED operations Detect, Defeat, Dispose, Divulge valid?

Discover the location, type of IED and component parts of the IED by information received from the local population, past incident reports, other third parties.

Detect by planned and controlled searching of the suspected hazardous area (SHA).

Defeat the component parts of the IED by blowing in place or using a render safe procedure.

Dispose of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.

Exploit and Disseminate from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority, mine action community and authorities component parts and reports as required.

**Considerations.**

- Is there a better different way to approach this?
- Is an operational structure needed?

Are the statements accurate?

**Answer**

The fundamentals provided above are not incorrect in my opinion however I would not choose to follow them. Below is a preferred format (within project specifics/boundaries). Discover; Cordon: establish a cordon, Control: control the area, Carryout isolation (as appropriate)
Detect; Carryout search method appropriate to establish device location (including isolation)
Defeat the component parts of the IED by blowing in place or using a render safe procedure.
Dispose of the main explosive charge in a safe manner in order to permanently remove the explosives from use. Recover as many component parts from the IED as possible.
Exploit and Disseminate from the IED sufficient understanding of the construction of the device to improve training techniques and procedures for render safe procedures. Make available to the home nation mine action authority, mine action community and authorities component parts and reports as required. Recording of device in situ may be valuable?

**Question 6.**

**Answer**

A risk assessment is a standard tool and applicable to any task carried out.
The NEQ limit would be dictated by the situation (location of Local nationals, cordon, CP etc), manufacturer rating of the equipment, value of the immediate infrastructure.
Mechanical IED removal should never be considered when the NEQ (main charge) is unknown and/or main charges in excess of the limit of the equipment are suspected and those points above.

**Question 7.**

**Answer**

The tasking system has two main influences;
1, Safety of the operational teams.
2, The organisation/individual providing financial compensation for the project (or their appointed director).
A clearance project is a working relationship between the ‘client’ and the clearance organisation, as such their ‘opinion’ (qualified and procured) should be valid and valuable.
Tasking systems are information led and as such directly reflect the quality of information provided.

**Question 8.**

**Answer**

Training programmes should always include a logical progression starting with the individual (training and assessment) and progressing through to scenario-based team assessments (IOT validate).
As above the most appropriate SME should deliver training to individuals, as such the Mech TFM could be that person.

Training should utilise all time available within a project but must cover the original criteria required. However excessive training as usually counterproductive.

**Role**: JV. Team Leader and Trainer **Operational Experience**: 10+ years

**Question 1.**

**Answer**

Generally there is initially lots of input from end user (operator) as to what's required and what would be desirable to have, however this is usually constrained by what's available in-country (capability wise), cost (project planning phase), movement of equipment to location and size of the asset.

There is always feedback on the machine during most day's activities, usually at end of day operations briefs, so any problems are usually highlighted quickly, depending on area of operations this does not mean any problems highlighted will be rectified quickly.

The machine I currently deploy as part of my Operations is both, it has been commercially modified (Armoured) and attachments have been altered / bespoke built to fit the purpose of what the machine is required to do, this has included strengthening, sound proofing, custom building a lifting arm for removal of IED's.

This is one area that is usually sadly lacking in both looking forward during the planning process (HQ Level) and maintaining a machine to keep Ops running daily. Logistically there is equipment's and parts for maintenance and servicing, specialist services from dealers may be required, fuel & storage and transportation to work sites, storage of machines (some sites may be several hours away from an operations base), security mechanisms for the machines when left overnight at a remote location. The machine also requires operators to be dual trained so they can operate and repair machinery to a basic standard if required. More serious repairs will need a properly trained individual / department.

**Question 2.**

**Answer**

This should be completed, however cost (sacrificial machine) and capability to perform such tests are often ignored or simply cannot be carried out for various reasons (Lack of testing areas, HNMAA not capable of conducting / validating tests. In demining many external company's offer machines tested against a known standard / NEQ of various Landmines etc, however with IED's the variables are far and varied this is due to the inherent nature of IEDS (different sizes of main charges / different main charges/HME used etc) As for charge size then risk assessment and threat assessment against known charge sizes for the area of Ops the machine will be deployed in should be set as the benchmark for charge size used in detonation and testing of a machines capability.

Normally a machine should be tested in 2 roles, working correctly and detonates an explosive quantity where it is envisaged and secondly at the location of the weakest known point where the operator is most at risk.

**Question 3.**

**Answer**

Repairs have sometimes been conducted where it is safe to do without comprising machine capability or safety, I have never experienced on site modifications as such. Normally anything that requires modifications need to be approved and granted permission from higher management (HNMAA), also the cost of such modifications has to be approved beforehand.

Sadly some modifications have not been tested and deployed on live sites, suggestions on my current program have come from a senior experienced Mech TFM for modifications we have conducted to machines employed.

**Question 4.**

**Answer**

This is dependent on the type of threat and risk (IED Type) likely to be encountered. If a component separation has been conducted and a trained IED operator has confirmed the separation and that all components parts are separated and safe (For storage and removal) then your QA process would normally entail a secondary search of the area (Minimum manpower usually - IEDD operator) / likely areas for possible secondary's (IED's / Switches). The deployment of assets such as K9 and or machine could be utilised but it has to be capable of providing assurance that the area has been thoroughly searched (as part of QA this may be 100% of area or a percentage), for QA purposes the use of 2 dogs QA'ing the same area may provide better assurance and confidence in the end product (Area safe and free from Explosive hazards)

The use of a machine for QA would normally be disturbance of the ground and environs (unless fitted with detection equipment, however in a urban environment there may be too many metallic variables) and you therefore potentially run the risk of a unplanned explosion, however this is a 50/50 scenario as deployment of machines means you run this risk anyway during clearance operations.

The variables of threat / risk / assets / building condition / security / speed of clearance / intelligence all have to be taken into account when selecting not only your clearance methodology but what QA methodology you will adapt also.

**Question 5.**

**Answer**

The above fundamentals grasp the concept of what is to be achieved in a logical sequence, each of these separate headings can where required be inputted with separate sub

headings, but this will depend on area and type of operations being conducted. The outline above by the author allow for this and as such are a good set of building blocks from which to expand where required when planning and conducting Operations.

There needs to be an operational structure in place from the Organisation to the HNMAA with results and outcomes being shared by all as part of a two way process. Operational structures will vary considerably on the size and structure of the organisation. NGO's generally tend to be smaller and less financially in a position to provide a Top heavy structure of personnel who have and can provide the necessary support and expertise to support this two way process. Commercial companies usually have better financial situations and therefore are in a better position to be able to provide.

Operational structures need to ensure they cover all the areas of Operations they envisage, far too often this is an afterthought and Ops suffer due to poor manning and staffing requirements for positions which have been an afterthought once Ops have started. This can often place unnecessary pressure on persons who may not necessarily have the correct experience or training for what's being asked of them. Far too often senior management in programs are less likely to request more staffing / expertise to ensure their ops and structure required is fully manned and functioning. Through experience as Operations have grown in size on programs and there is a clear requirement for extra staff / personnel this is usually rejected as financial implications have not been previously thought of during initial planning phases. As stated above this often means that personnel are often 'double hatted' to fulfil a role they may not necessarily be capable of doing.

**Question 6.**

**Answer**

Risk assessment and threat assessment should be combined when planning to use mechanical assets for the removal / RSP of IED's. A machine gives some degree of confidence of safety to the operator due to the armour and standoff it provides, at best it is a semi remote method of removing IED's. Therefore the risk and threat need to be assessed together. A machine cannot give the same dexterity as a human operator can when it comes to dealing / RSP with IED's. Therefore it should not be considered as the lone option but considered as a tool as part of a 'Toolbox' approach when deciding on whether to be used.

The term risk assessment when used in a IED context is to be coupled with threat assessment and SOP's which give detailed instructions on capabilities and limitations on what can be used, where it can be used and against what target. This information from all these sources are then used when deciding the preferred RSP.

The EOD industry as a whole has been discussing for the last few years on how Risk assessments and what they should contain/ be captured and documented as a single process / document. This I feel will continue on for some time yet.

NEQ limit should be what the machine is tested to (If tested) ? however other factors such as location of the IED, method of functioning, Main charge size, IED Role (Blast, Blast/Frag, Shaped Charge) all have to be taken into consideration when deciding on employment of a machine versus Human operator.

Mechanical should not be decided / considered in the following:

1. A building structure is unsafe (potential collapse and trapping machine and operator),
2. Does not have correct armour capabilities,
3. Machine operator does not have correct training,
4. No SOP's produced to detail procedures on machine employment
5. No means of rescue if Machine operator if injured
6. No medical capability and CASEVAC on site during Operations.
7. IED size / Role or method of functioning means the machine and operator are potentially at more harm by deployment versus a human operator tasked to conduct the RSP.
8. Should not be deployed in a role it does not have accreditation for by the HNMAA
9. No means of communicating with the driver / machine operator from a safe distance

The above are generic type examples and as such more considerations may be added depending on what the actual task is, the machine although seen as a liability and for all intent purposes expendable to some degree should not be a considering factor when deployed, the safety of the machine operator is absolute paramount and has to be considered. This again relates back to Risk / Threat / SOP's.

**Question 7.**

**Answer**

Clearance organisations should give their opinion on tasking systems to the HNMAA, it needs to be a two way process as far too often a HNMAA will just have a list of areas for clearance and in their minds they will be cleared in a semi systematic way according to them, however take for example a NGO who has received funding for clearance, they may have received these monies based on working within a geographical footprint only, this may not align with the HNMAA overall clearance plan.

Tasking systems far too often are complicated, paperwork heavy and often require permissions from several departments within a HNMAA which can and often does lead to delays and issuing of tasks, which can lead to teams being stood down and waiting, this is considered not finically value for money to the donors.

HNMAA's need to look and discuss with Organisations and companies what their current funding allows them to do / work. This then means that HNMAA can issue tasks relevant to each Organisation donor / contract requirements.

Sharing of information about what tasks are available from the HNMAA also would help when deciding on tasking systems. As this means operational plans can be foreseen, tasks can be applied for and given, meaning Organisations can plan ahead and task teams with minimum disruption and stand down times.

Tasking systems have in many cases been over complicated and lengthy due to processes developed by incorrectly employed staff / departments within a HNMAA. There is also the geographical region of where you are operating to take into account, many countries / areas of operations do not have the same approach / attitude / staff capability as some more international Organisations have. HNMAA often lack funding from their own internal governments, staff employed in many cases have been incorrectly chosen due to their relationships with senior figures in the HNMAA etc. There is also the electronic structures to take into account that may or may not be available, some countries because of this rely heavily on paperwork to process / allocate tasking, if you have a lengthy paperwork process spread over several departments within a HNMAA this will and does cause problems, if an electronic tasking system / allocation system is in place this helps speed up the process.

The tasking process can also be effectively hijacked by other external Organisations (The United Nations is a great example of this), they often provide assistance to HNMAA's but far too often end up controlling the HNMAA because of the fact they bring monies to the situation, this often means that HNMAA's often surrender themselves to the financial side of this situation. The UN as an example often use this as a way of controlling all organisations and companies and as such use this as a means of control to conduct tasking to their outputs and objectives and not necessarily listen to the requirements of the people on the ground actually conducting the clearance and removal of explosive hazards.

**Question 8.**

**Answer**

Suggested elements for training

1. Machine operation – deployment and correct use / limitations of machine by the operator
2. Maintenance and servicing
3. Intro to IEDS (Types, roles, method of functioning, deployment TTP's used)
4. Actions on – planned explosion, unplanned explosion, CASEVAC, Break down (Inside and outside of any danger areas), methods of recovery for Machine)
5. First Aid and CASEVAC
6. Comms trg
7. SOP's
8. Reporting
9. Practical trg and assessment

10. Mentoring by a qualified and experienced Mech TFM

Trg depending on machine type/s, area of operations would normally last between 4-6 weeks.

There is a absolute need and duty of care by the employer to employ a senior Mech TFM to oversee, develop and conduct the training with assistance from other departments where required for aspects of the trg course.

TFM's and TL's should be included for various aspect / parts of the course (serials 1,4 and 5 above)

**Role**: BL. Mechanical Supervisor **Operational Experience**: 20+ years

**Question 1.**

**Answer**

In a vast majority of cases the machinery selected is manufacturer led. With the claims of their machines being perfect for customer needs, but these machines are being tested in conditions that are prescribed and in accordance to manufacturers claims, meaning next to ideal test conditions. So usually the test results are good.

Although there are independent authorities that do conduct trials, this is usually on a small scale due to funding such trials, and these trials are only to verify manufactures claims.

But it as to be remembered that there are numerous factors that can have adverse effects on the performance of each machine, especially within the IED role, more of this later.

In many clearance programmes, machines are selected by individuals who have the authority to select machines for procurement, who having limited experience or knowledge of what a machine is capable of, or what are the real working conditions are like. These individuals who get to choose, usually choose from previous experience of a machine that they have seen before or know people who have used a similar machine before.

Remember what may have proved to be ideal in one task/program, may not be ideal for the other task/program.

Note, it is usual for a small management team heading up a potential start up clearance programmes, to start planning what the requirements are going to be, way before staff for the programme are recruited. With end user usually the last to be recruited.

But sales pitch from the manufacturer who state that their machine is easy to use, maintain and user friendly are normally miss-leading. Also, whilst the machine is functioning normally, they tend to be relatively straight forward to use, but once something goes wrong, then the problems start.

As to input from end user to manufacturer, this has proven to be limited in my experience, especially when lines of communication must be respected within the employing organization.

As most management positions have their own fields of expertise to concentrate upon, who in turn offer their own interpretation of any issues, but it could prove beneficial to all parties if a direct line of communication could be established between end user and manufacturer, as it in every ones interest to have a viable and successful machine.

As to modifications, the robotic machine currently employed has had several bespoke modifications made to it, but these are available from the manufacturer, but where not precured, due to lack of information or detail, as to how the machine was to be employed. But end application and areas of operations have to be taken into consideration in each location, the Armtrac 20T was procured mainly to deal with conventional AP minefield, but due to the selection of a flail over a tiller, this proved to be the wrong choice, again local conditions need to be factored in before machine/tool selection.

Flails verses Tillers, the pro's and con's of each is a complete documentation on its on its own, has performance are greatly effected by the design of the hammers and the rotational speed of the flail/tiller.

Example too much stone contamination and soil with a high lime and silt combination tends to harden up like concrete, rendering a flail system in effective, but this can be compensated by types of hammers used on the flail.

However, this machine did come with two grapples (Large & Small) with the intent to handle IEDs, but in open areas with good access, not for building clearance, in which this machine is now mainly employed. These grabs are mounted onto a backhoe, so their agility is somewhat limited.

As these machine are designed to work within an high risk environment with the potential to receive damage from any intentional or un-intentional detonations, then a workshop facilities need to be able to provide good fabrication/repair facilities with good lifting equipment to carryout repairs in a safe and efficient manner.

Also, logistical issues need to be taken into consideration such as transport and recovery of selected machine, although the Armtrac came with Trailers they are too heavy to be towed behind a B6 converted SUV. Recovery also proved to be an issue, the original two-machines did not have the ability to be towed out of minefield, they where designed to be lifted by crane, which in-cured clearance issues within a contaminated area to allow access for the crane.

A classic example of not thinking forward in the planning phase, was witnessed in Cambodia in 2000, where the Local UMAS had acquired a very large mine clearance machine, called a Rhino all 42 tons of it, during trials it proved to be a very promising machine, clearing all within its path with ease.

But unfortunately following the trial, it sat in a yard waiting to be collected by the supplier. Why? Because, due to its weight and that it needed of a low Loader to transport it around

the country to perform it tasks, following the war, there where no bridges in the whole country that could take the weight of this package, so it became a white elephant.

**Question 2.**

**Answer**

All machines should be tested prior to deployment to ensure safe working practices and to learn of machine capabilities and limitations, as IEDs come in all shapes and sizes, with the unknown factor of explosive content composition.

Manufacturers should and normally will supply test verification against specified detonations, but remember it's only the operational tool that is tested, as in most cases the base machine would not survive a direct hit upon its chassis or means of traction (Wheeled or Tracked) therefore the size of any independent testing should not exceed the manufacturers verifications, again IEDs are not uniform they come in all shapes and sizes, all tests to be conducted on working tool in contact with IED, unless the manufacturer states that the machine in its entirety is survivable.

Other factors like access need to be taken into consideration, as with most devices, defeating the device is relatively straight forward for the expert, but the hardest part is locating, and identification of detonation device is the tricky and dangerous part of the task. So the machine is designed to handle IEDs but it need to get to it first, intelligence is need first especially if located within a building with potential booby traps, a good surveillance system is needed to get eyes on within the target structure. This usually hindered by rubble mass, once the target has been identified and a plan of action is made the access is required, so is the machine capable of being multi-tooled do carry out these tasks?

**Question 3.**

**Answer**

Providing the skill set is available with good workshop facilities then most machines can be modified in one way or another to adapt to local needs, as the supplier usually caters to a specific tasks such as handling a device to relocate it for example, but most IEDs have to be located first, followed by access, so it's common to make adaptions to aid in these needs (Search & Access).

Examples:

Bucket on robotic arm

Blades for scrapping debris away from target fitted on robotic arm

Cutters (Like scissors) on robotic arm

Hook to pull barbed wire on robotic arm

Front end bucket to remove rubble

Front end blade to remove rubble

Winches to drag large items

Most are tested on trial runs using Free from Explosives devices to test the efficiency of the bespoke device.

Most bespoke devices are a result from prior experience from team leaders who have seen such devices before, or from individuals that have made adaptions of proven devices.

**Question 4**.

Answer

IMAS state there has to be three means of clearance to ensure full clearance, which means is used first is dependent upon the local explosive threat and the choice of the clearance team leader, but note if dogs are to be used following mechanical means, then there has to be a sock period (Normally 24 hours, but can vary depending on local threat assessment) Normally verification is conducted by varying means, but a machine with a different type of clearance system could be employed to verify QA.

**Question 5.**

**Answer**

All the above is correct and can be expanded, but the main issue is management and control, all the intelligence needs to be gathered and assimilated, to ensure good safe working practices ae employed, are the right staff employed to deal with the current threat. As with machines one TFM may have been a highly skilled individual on a previous project but are they current with the relevant knowledge to deal with their new task, sites vary from site to site country to country threat to threat and so on.

As with most devices, neutralizing the threat is usually the easiest part, locating and identifying the initiation mechanism is the more complex. With the risk of multiple initiation devices with a long-life power source, makes this task extremely difficult, hence why machines with sacrificial parts, should be employed more, to ensure individual safety.

**Question 6.**

Answer

Is the machine designed to withstand the potential detonation or just the operating tool, what are the chances of multiple detonations from other directions, which could incapacitate the machine, leading to a higher risk to individuals when recovering this machine?

What is the specified classification of the machine as stated by the manufacturers?

Machines should never be used when there are risks of multiple charges.

**Question 7.**

**Answer**

Mine Action authorities are good to ensure overall control of basic procedures and principles, but the local clearance agency must have the right to decide what actions to take in mitigating risks, as local threats differ from local to local. With some areas having a signature of types of techniques used by the groups who set up the explosive threat.

**Question 8.**

**Answer**

Mechanical training should encompass all aspects of the demining technology, as these operators will be operating within a threat area, so individuals should have basic knowledge of those around them, as to be compliant with SOPs.

Training should include all parties who will be working with machines, so a good understanding of capabilities and limitations are understood, as to enhance performance and to increase safety, to all those within the threat area.

If available a subject matter expert should be recruited to deliver training in any aspect of IED/UXO clearance, as each machine has its own limitations and again what might have been a good machine in one program does not mean it will be a good machine in the next program of clearance.

So, a Mechanical TFM, who should have multiple skills and experience in a variety of machines, should be involved in training, othering insight into all aspects of clearance and potential solutions to mechanical issues.

Other considerations: -

When selecting a machine, as said earlier it is important to ensure what the end user expectations are, what is the local threat and what is the skills level of operators.

Other considerations include Service and support, are spares and maintenance parts easily available, are the local skills suitable to conduct technical repairs in the event of a major or technical failure.

Is the whole machine to be sturdy enough to withstand accidental detonation, or just the IED handling tool?

Is the machine cost efficient, would it not be better to employ local staff following training than to use an expensive machine, this would bring employment to locals who are trying to rebuild their lives following conflict?

Is the machine a one off designed for a specified task, making it an expensive part of the deminers toolbox, or a multiple tool based machine, which would have a multiple role offering a more cost efficient machine, the more attachments available then the machine can be used in multiple roles, making it more useful.

**Role**: VH. Fleet Manager **Operational Experience**: 20+ years

**Question 1.**

**Answer**

Machines were pre-selected & procured by Senior Project management (not actual end user or SME)and delivered to AOR. 4/6 machines were not initially designed for Demining/IED operations.

4/6 machines were originally construction site type heavy plant machinery. This type plant required an overhaul, entailing, the design, construct and fit of armour, ballistic glass, and bespoke wheels (if not tracked). End product designed to withstand small detonations when used in intrusive role. End user modified machine as much as possible within the parameters of original chassis, engine, boom & hydraulics.

2/6 commercial machines (again, pre-selected & procured by Senior Project Management) were designed for traditional Demining type usage. Tactical level Modifications for the IED role were carried out IOT improve and widen the machines capability and role within the Urban environment

To support mechanical/machine operations, an equipped workshops, with trained staff under the supervision of a Mech SME and a supply line that reaches out to vendors capable of supplying OEM parts is a requisite for an enduring project.

In the main, machine is manufacture led, with end user modifying and adapting within parameters of local environment circumstances (human and material resource)

User or field data is captured and fed back through the relevant org chain, where practical, modifications, improvements or additional spares are authorised.

**Question 2.**

**Answer**

Machines should be capable of withstanding small detonation. Detonation is a possible and potential by product of IED removal. Machine should be recoverable, fixable at tactical/local level after exposure to AP size device.

Commercial manufacturers will always have the resource and means to design, construct and test for detonation.

Local manufacturers (workshops) will have neither the resource, material or data collection apparatus to carry out such tests. In this scenario, the designer (MOM) is reliant on data provided by other Industry service providers, such as UNMAS, who will provide known and tested specifications, such as steel plating, glass, etc to be fitted.

**Question 3.**

**Answer**

Modifications have been carried out to improve, operational use, this includes the fabrication of buckets & flails. In addition, extra anchorage points attached to enable the safe lifting from ground to height. Other modifications have included an override to the hydraulic system to aid recovery should a track sprocket be damaged.

Test conducted at tactical local level, with results recorded in machine ORK log.

**Question 4**. No answer.

**Question 5.** No answer.

**Question 6.** No answer.

**Question 7.** No answer.

**Question 8.**

**Answer**

Awareness/Overview Brief: All (1/2 morning)

- Machine Characteristics, capability & primary functions

Specialised Training: Selected Search Team Members (1/2 day)

- Spotting Duties (incl Radio VP)
- Ground Guide Drills & SOP

TL & TFM ( 1 Day)

- Above
- Operational Considerations, limitations & Planning factors (machine & operator)
- Combined Arms Estimate Ex (searcher, machine, K9 or Hybrid thereof for intrusive/non intrusive ops)

SME to deliver training and to be prepared to offer technical advice and input to SOM & TFM throughout planning and execution phases of clearance/removal ops.

**Role**: PC. Logistics Manager **Operational Experience**: 10+ years

**Question 1.**

**Answer**

I am going to assume it is manufacturer led in a commercial environment with input from the end user, however, how much relevance the end user input is in relation to manufacture delivery is debatable. One end user's observations and feedback may contradict another user's input – more so with the differing usage of equipment's and the differing expectations of end users.

Modifications to commercially supplied machinery will take place by end user to enable the end user to better refine equipment for specific task – does this feed back into manufacturer and become standard – unlikely, again, due to the diversity of use. Additionally, there must be cost implications as well as safety and suitability – my "perfect" requirement may not be the requirement of other users.

I think both end user and manufacturer affect the design but only within limitations of differing Country standards, cost, safety and undoubtedly, with any commercial practice – the bottom line or profit margin.

**Question 2.**

**Answer**

There should be a test on elements of the machinery, but again, how do you test against something that cannot be quantified. Different standards along with different exposures will

affect both the requirement, the budget, the profit margin and as such I do not think could be sustained.

I believe the basic requirement as per the Host Nation standards should be met (Armour thickness) but the actual specific requirements based on end user should be bespoke. Why restrict one person's operation with excessive requirements of another person's operation, impacting possible uses and budgetary constraints unnecessarily.

**Question 3.**

**Answer**

I am going to assume modifications are made based on individual user – however, are they successful, are they legal, are they safe, are they approved – I would suggest not.

Individual users and human nature make us want to change things based on our own experience – are these changes for the better or just a "quick fix" to achieve a single aim.

Testing of modifications would be assessed by the fact "it got the job done" so effectively it was or has been tested but not to a specific or quantifiable standard and although it may have worked in that particular scenario – would it work again.

Diversity of use and requirement along with budgetary constraints seem to be a recurring factor in a lot of these answers.

**Question 4**.

**Answer**

For me as a non IED individual, I would suggest the most stringent of QA is required – in reality, the minimum will be applied. Equally – how do we quantify the QA Standard when there are so many diverse requirements of the machinery and without large financial input, how do we assess technical equipment if exposed to unknown blast damage – each blast would be different.

For the ground clearance – then I assume normal QA process as per AOR SOP's would suffice, as long as the process is evolving and not restricted to a QA archaic check sheet.

**Question 5.**

**Answer**

Seems a thorough and well thought out process, however, in reality – does this happen? Are there unknowns that prevent this from happening? Does human nature and ego get in the way of fact?

Unfortunately, whatever we do, there is a human factor and that very rarely seems to be considered – be it the ego of an individual or the experience – they are all factors that could undermine the above process – we have seen this.

How do we solve this – again, budgetary constraints will play a factor, so we have to find a happy medium and build on this – learn from our past experiences, document our learning,

continually update policy. So effectively – what you have said above is true and accurate today, but what will be true and accurate tomorrow?

**Question 6.**

**Answer**

Ultimately, Safety will be the main factor, however, other factors must include damage limitation, preservation of evidence, cost implications.

Risk assessment could be a starting point for the task, however, this must be used as a guide and tool as opposed to a rigorous check-sheet. Different mechanical assets and different devices along with stability of device / age of device / location of device / size of device / familiarity of device – all these play a factor in the final decision and one person's assessment may differ from another – ego plays a factor.

It would be hypothetical to assume mechanical should never be used – again, all devices should be "risk assessed" to ensure best practice to deal with that "specific individual threat" – all are different on so many levels.

**Question 7.**

**Answer**

No – the emphasis on clearing operations should stay firmly with the end user / operator / SME OTG. Host Nation authoritative bodies can collate best practice from all players and disseminate what they consider best practice, but you can definitely not manage the actual process of clearance from a desk autonomous from the location.

To build a good understanding and for information sharing and "guidance" then clearance organisations can and are a good asset, but the limit of their input must be advisory. All reputable organisations will be working from the same standard, often interpreted differently – so the clearance organisation is a good asset to control the interpretation of standards but should not be able to direct the concept of operations.

**Question 8.**

**Answer**

I think the training program should be structured to the trainees. All personnel should be included but the level of content and instruction must be focussed on what they need to know. Continuation training and practical hands on would be encouraged. An SME must deliver training – otherwise it becomes an information brief as opposed to a training session. How do you put a time on training? It should be as long as required to ensure the trainees are at the required standard to safely and competently achieve what is required of them.

**Role**: RO. Technical Field Manager **Operational Experience**: 20+ years

**Question 1.**

**Answer**

- The Mechanical assets are end user led. We had to get a local manufacturer to construct and retro fit the steel armour plating for the driver's cab. The Local National Demining Company employed by our company TT (author change) acquires the Mechanical asset (JCB or 360 Excavator) and then we retro fit the armour steel plating in accordance with TT (author change) Mechanised Standing Operating Procedures. This is then put through a series of tests prior to use on a task. A full Quality Control is conducted on the asset.
- TT (author change) selects the assets and then the Local National Demining Company procures the assets and the company then rents these assets on a daily basis.
- Feedback is conducted on a daily basis firstly a full First Parade of the vehicle is conducted to make sure the asset is serviceable. The first parade sheet is filled in daily to show this has been done. The mechanised assets are also recorded in our daily site reports on Fulcrum. Quality Control also conducts visits and also conducts reports on all the mechanical assets. All the reports are seen daily by our Operations Manager, Deputy Task Order Leader and Task Order Leader.
- All our mechanical assets are modified by a Local National Contractor. Then this asset is then inspected prior to its use. If we see any further modifications, then we raise this our management and discuss the problem and then get the modification sanctioned and rectified. An example of this was when a mechanical asset was working in dense contaminated metal and rubble area the tyre valves were being sheared off by the metal. To stop the happening again we modified a steel plate cover to protect all the valves on the mechanical asset.
- The Local National Demining Company control the full maintenance schedule of all the Mechanical Assets. All oils and lubrication are done monthly due to heavy use on top of the routine inspections. The Local National Demining Company also transports the Mechanical Assets to and from the Work Site.

**Question 2.**

**Answer**

• Yes, I think tests should be done this will highlight any strengths and weaknesses with the IED Removal Machine.

• I would put the Net Explosive Quantity as the most recovered Main Charge in the theatre of operations. In Iraq where I am working that is a 20Kg Main Charge.

• I would definitely place one device in the middle underside of a vehicle as the tracks normally triggers the Firing Device Switch. Second device I would place near any digging

tool that is being used. From the outcome of the explosive test you will then see what needs to be strengthened and what does not.

**Question 3.**

**Answer**

- Onsite temporary modifications can be made to complete a task. We improvise sometimes to get the task done. These modifications will be discussed using a referral method to the operations manager or by conducting a Pre-Plan Operation.
- The most useful modification we have used is fitting ceramic blades to our Remote Operating Vehicle.
- Tests were carried out in-house on the training ground to get the best angle and cutting position.
- The operators suggested they needed the capability to cut Command Wires and Remote-Control Packs out of an Improvised Explosive Device. This was then trialled to make sure this functioned as intend prior to its use on the ground.

**Question 4**.

**Answer**

- After component separation we can use two methods a Remote Operating Vehicle (ROV) or an Unmanned Aerial Vehicle (UAV) to survey the component parts and to confirm separation. The Operator will then go down and confirm this manually.
- K9 and a Search Team can be utilised to carry out a 20% QA of the task site. The K9 does have limitations when it comes to earth mounds so in this case a Search Team is better equipped to deal with that scenario.
- I personally would not recommend using another machine to QA as you are not going to guarantee the area is fully checked to the SOPs.

**Question 5.**

**Answer**

• Yes, the Authors fundamentals of IED Operations are valid. These are the proven building blocks that have prevented countless lives being lost. Also, countless attacks on the civilian population from happing by recovering component parts exploiting them and shutting down the networks.

• I think we are doing the best way possible but there is always new technology and ways to do things better and we always adapt to the ever-changing environment.

• There already is in place a good structure from the Project Manager, Operations Manager, Team Leader, Search Team Leader and Improvised Explosive Device Disposal Operator and back up the chain of command. The Military also have the same systems in place.

- Yes, the statements are very accurate and in line with current SOPs and Philosophies and Principles.

**Question 6.**

**Answer**

- IEDs are broken down into Time, Command and Victim Operated. All threat assessments will be conducted, and the extraction planned prior to any IED being moved by a Mechanical Asset. You also have to consider whilst you move this device it could initiate! All safety precautions will need to be put in place prior to any movement of a device. As an example, VS500 ISIS Improvised Mines (Copy of the Italian VS50) where removed very successfully in Mosul using a Mechanical Asset.
- We call it Threat Assessment which is very similar to Risk Assessment. This tool has worked very well but has been perfected over many years and is a continuing to be developed when we see new IEDs arise.
- This is a question that has been asked many times. My personal take on this is if you want to say preserve a historic building or an asset (Cancer Machine) why would you want to potential destroy these when there is another way to deal with the IED. Mechanical Assets can function the switch on a device if moved or hit with the teeth on the bucket.

**Question 7.**

**Answer**

- This massively depends on the contract and the donors. I have worked on both sides of the equation. Working directly at the remit of the HNMAA can sometimes be very hard and challenging. We can advise and recommend the HNMAA as Subject Matter Experts the best way to deal with a task site or IEDs.
- Organizations should be allowed to give their opinion as I have worked with some people in HNMAA who have no idea what an IED is? In some instances, this is why experts have been brought in to solve the issues as their own Operators where not up to the task of clearing complex devices (Anti-Lift).
- The advice we would give the HNMAA is explosive safety, Time Frames to complete a task, Assets to complete a task and QC & QA of the task site prior to any completion. We do this by conducting a Non-Technical Survey and from this we will see the Threat we are faced with. An Implementation Plan will be produced and this with show the clearance level and assets required to clear the task site. Once the task site is clear and QC, we will then conduct a completion report for the HNMAA. This report will include any Search Restrictions. We try not to have over a site with

any Search Restrictions. However, if there is, we still work closely until this has been removed by another agency and then the report will be adjusted.

- The biggest flaws I have seen is making companies lives difficult to conduct a simple spot task. These tasks are quick fix wins for critical infrastructure. Normally this is a task that can be done in a single day but the HNMAA make it a mountain of paperwork when one IED report should suffice. Also having non-qualified IED Operators within the HNMAA is a massive mistake as they have no concept of how operations are conducted.

**Question 8.**

**Answer**

• This is a generic list of what I would aim to use for a Mechanical Asset Training Program:

First and Last Parades, Mechanical Asset Limitations, Tools and Equipment, Communications, Spotters Role, Mounting the camera, Medical Training and Casualty Evacuation Drills for the Asset, Training Tasks and Assessment Tasks.

• I think the balance is about right TFM`s and TL. I would probably do training days for the Searchers where they would have an introduction to Mechanised Assets.

• Yes, I think a dedicated Mechanical TFM would be very beneficial especially if you are in a large built up area. The advantages of this is over time you will save time and money clearing areas up as the TFM gets more experience and knowledge how to conduct these difficult clearance methods.

• I think the training should be a minimum of a week and a maximum of two weeks.

**Role**: AA. Safety & Quality Manager **Operational Experience**: 20+ years

**Question 1.**

**Answer**

End user lead but manufactures sometimes will have input thru their expertise of their products. The end user generally does have input on the design and capabilities. If the end user did not the manufacturer would not know the spec to build their machines.

Some input I would want or have is what is the requirements needed for the task at hand. Is this machine a one task use machine, or will it be bought by the company and used for several tasks. What are the capabilities and limitations of this machine? What Armor spec is required for task. Does the NMAA have a spec for machines with regards to Armor.

Yes I provide feedback on the effectiveness of our equipment.

Yes every piece of machinery we are currently using is or was a commercial equipment, that has/ had an Armor cab built around it.

Pre & Post operation checklists, basic assortment of fluids for equipment, Mechanic to fix the equipment when it is broken down. Dedicated fire extinguishers, evac training with Mech Operator, Radios.

**Question 2.**

No different from protocols already established for UXO construction sites, Mine Action sites. Etc…

**Question 3.**

**Answer**

Possibly, many times in this field scenarios come up in which there is no “Tool” made. This is why outside of the box/ creative thinkers strive in this field.

To many modifications to list

They are generally all tested prior to being implemented into the field.

Suggestions are made thru team work, networking, reaching out into the community for answers, chances are someone out there as done or heard about a similar scenario you are doing. And if they have not minds pulling together will come up with an answer.

**Question 4**.

**Answer**

Verification of separation of components can be completed several ways. Military used robots, drones, drive by in armoured equipment, cameras, detectors, bomb suit, walk down and look. Etc…

Now if your talking about after an item is cleared and the need to QC the area, then all of the above, as well as using detectors to verify no items are present, as well as K9’s this is to broad of a question to get a simple answer.

K9’s are one step in the process but there will always be a requirement to have a man go down and conduct positive QC on an area. I personally would never leave the last QC up to an K9. I person physically needs to check and verify.

**Question 5.**

**Answer**

This is pretty much how it is done, you can re-name, re-word, re-address how you want but in the end this simplified statement is what it will always be broken down into.

There is and will always need to be an operational structure of some type or format. Statements above are accurate.

**Question 6.**

**Answer**

There always needs to be a risk assessment in any operation. This is what we do to identify, minimize, and prevent accident/ incidents from happening.

The NEQ limit is going to depend on the capabilities and limitations of the equipment we are working with. If have a piece of equipment that cannot withstand a 20Kg blast, but that equipment is low cost and operates remotely from a safe distance then in all honesty the NEQ limit is not my concerning factor in using that equipment. My safe distance and the ability to use that equipment at a safe distance is. We can skin this cat a few different ways, but in the end the bottom line is. Can we conduct this operation with minimal risk of injury and minimize the cost if & when a detonation occurs? “is the juice worth the squeeze”

There are very few instances where is should Never be considered. Protection of life, (hostage bomb), protection of historical asset/ value, monuments, etc.. but generally if it is safe to do so and we have the capability why not.

**Question 7.**

**Answer**

They do this all the time. It is how business is done. If XXX donor only wants to clear XXX type of sites, then they are going to get what they want or they won’t donate.

Advise is have a process written down so every company, NGO, organization can follow.

Flaws, not having a process, procedure, spec. making up processes on the fly. Not having a set of Mine Action Standards to follow.

**Question 8.**

**Answer**

The TFM’s & TL’s need to understand how to the limitations & capa bilites of the equipment they have on site. They need to understand how to implement, utilize, & supervise those operations.

There should be training conducted, most of this will come with experience. But a requirement I would say no unless you have a very inexperienced crew utilizing mech.

No more than a few days to understand what the capabilities are, limitations are, safety processes and procedures for using mech on a site

**Role**: GM. Team Leader **Operational Experience**: 10+ years

**Question 1.**

**Answer**

IED removal (or for some project’s Improvised Land Mines ILM’s) in the urban environment is still a developing concept, as opposed to mechanical minefield clearance which has been going on for decades now. In an immediate post conflict area the end user may have difficulty obtaining a bespoke type machine and having it shipped into a country which from a governmental view may be in disarray and customs etc may not function as expected, ergo it is highly likely that the machine will be sourced in country after much discussion within a project to develop the requirements of the machine versus what is commercially available.

To that end the requirement will be user led with the project staff dictating what modifications or onboard tools are required/available with the manufacturer then producing a machine that meets the required spec.

Project staff will ultimately present what requirements they have for a machine that best suits the project it will be utilised on, but a large factor in the decision making will be the cost of the machine and also the cost of what upgrades may be required on it. The steerage of this will be determined by such things as, is the client will to accept being back charged for the clearance machine as a project add on, or, will the clearance contractor be willing to absorb the cost of the machine in the long term as an asset, or, are machines available for hire and do they meet the spec required or can the vendor make the required modifications.

The machinery I have seen so far has been commercially available plant which has been up-armoured locally with limited IED removal tools on it due to the attraction rate on the machine when subjected to a high order detonation as a result of the works being carried out.

Logistically the owner/operator must be prepared to suffer a total loss of the machine in the event of a detonation, in a sense of plan for the worst but hope for the best. The operator of the machine should be able to carry out first line repairs such as bucket/tool removal and replacement, and also general serving duties as would normally be expected, oil/air filter cleaning and changing etc.

Second line repairs should be locally available to provide such things as repair/replacement of hydraulic hoses and rams in the event of blast damage.

**Question 2.**

**Answer**

Assuming the role of the machine is not to detonate a device, rather than detonation as a means of clearance with manual clearance then taking place afterwards, the object of the machine should be survivability of A-any human operator (rather than an RC machine) and the B-the survivability of the machine to either carry on operating or be subject to 1st/2nd line repairs and then return to service.

My own thoughts on subjecting the machine to a detonation is that I would disagree with that process being carried out. In demining operations anti-personnel land mines will typically contain 50-100gm of high explosive, this means that detonation of such a device is not likely to adversely affect a machine and such a sized detonation can be mitigated against.

IED's "currently in service" are typically 10-20kg NEQ and sometimes much higher than that, this would produce a much more devastating blast hazard and to subject a machine to such a test may well render it unusable. It would be wiser to explore a set standard of armouring such a machine to ensure survivability of the operator using test cases where such an incident has taken place and the operator survived, i.e. what was the machine, how was it

armoured, what size blast was it subjected to and what if any damage was sustained, and manufacture a machine to that standard using a number of incidents to produce a common denominator as a standard.

Point of detonation is likely to be at the tool head, be this a front-loading shovel/bucket, a rear operated backhoe, or some form of telescopic arm used to lift/sift ground to expose a device. However, the drive train of the vehicle should also be considered as a point of detonation and wheels/tracks being subject to blast damage. To that end if any T&A blast be carried out its likely that only tool heads would subject to testing as track/wheeled areas would suffer catastrophic damage in the test.

**Question 3.**

**Answer**

I have only seen traditional front-loading plant machines in use, including armoured cab tipper trucks. I have seen no add on tools that have been put on for IED removal. What has been witnessed is standard plant that has an armoured cab of sheet steel with B6 type glass fitted.

One such machine was subject to a 20kg NEQ blast in Ramadi when the front-loading bucket initiated the blast. The blast was largely contained by the bucket and the shape of the bucket deflected the blast away from the cab. The machine survived without the need for mechanical repair and the driver/operator was uninjured.

I am not aware of what testing procedures were carried out or if it was accredited by NMAA standards.

**Question 4**.

**Answer**

In terms of component separation, I have not seen a mechanical or energetics means of component separation used in Iraq due to the government not allowing commercial agencies to use energetics which also includes Thermite, a benign and stable compound with no haz-mat requirements until it is ignited. All component separation has been manually completed.

The QA process after this has been site managers carrying out a minimum of a 10% check of areas cleared, with the option of the client also carrying out a QA either themselves or with a 3rd party in place.

I would not use K9's as a QC, they are useful as an area reduction tool along with other AR methods, but my own belief and current SOP usage is an operator with a detector checking the area after all metallic content has been removed, even after such things as flail use etc the area still needs a human element with a detector to clear the area.

Currently in the UK there is a drone company which uses large drones with detectors that will detect and map any caesium content in explosives as a means of area¬ reduction and locating legacy LSA, normally used as a pre-cursor to clearance and repurposing of former

military ranges. It may be in the near future that such a device or method could be used for area reduction or QA purposes in a post conflict sense, this is currently difficult to do because of the weaponization of drones means that use of drones is viewed as highly suspicious.

Research http://www.chilbolton.org

In relation to other machines carrying out QA, for the current to mid term view, QA will be human operators with detectors.

**Question 5.**

**Answer**

I am in agreement that the above is largely correct however the divulge part is a very grey area, some of which may be contractual, i.e. UNMAS as a client will not look to exploit from a forensics point of view to maintain its stance as a neutral organisation. Some commercial companies will not share information on finds or indeed fatal incidents in case it should compromise their own operations, a broad-brush statement here but US based companies are generally willing to suck up any information on finds and incidents but will not trade as such at a company level. It may be that at staff level there are friends and military acquaintances in place so that information would be shared on a person to person to basis but not at company level.

I would agree that the other aspects of this question are correct and valid. SOP's may vary slightly from company to company or theatre of operations but as a slightly sweeping statement they are all true and valid.

In terms of a better way to approach this, SOP's may vary slightly but the process will always be the same, TS/NTS, AR and then plan/commence search operations.

An operational structure will, for obvious reasons, mirror a NATO type military doctrine based on depth of experience in operational theatres ranging from but not limited to Northern Ireland circa 1970's-90's, Iraq campaigns and more recently Afghanistan. It is reasonable to assume that the next large scale commercial-NGO theatre of operations will be Yemen, a puppeteer conflict between two middle eastern countries with two different military doctrines, mainly NATO based on the Saudi side and Soviet based on the Iranian side, but the modern Iranian history of asymmetric warfare will certainly present an IED threat in Yemen as well as a traditional LSA hazard and it will be interesting to see if current SOP's in use in Iraq/Syria will be fit for purpose in Yemen or will the asymmetric nature of the campaign develop a different threat.

The disposal of devices is not always a pre-requisite. Although the Iraqi stance is not allowing the use of energetics outside of the national army, the Syrian government is open to allowing the use of energetics in clearance methods. The acquisition of such energetics inside Syria is difficult, the acquisition of them outside of Syria and them shipping them into

the country and onto projects would be costly, difficult to carry out logistically, and not without risk of incident or banditry along the supply route.

The most efficient means of obtaining demolition charges and detonating trains is the manual disruption of IED's and the repurposing of the component parts as demolition equipment. The main charges and detonators are in plentiful supply, what lacks is detonating cord, this is normally acquired through good relations with friendly military units in theatre.

**Question 6.**

**Answer**

This is difficult because I am not an IEDD operator. The first thought when dealing with an IED is that the operator/company must be willing to accept all the risks of a high order detonation and the damage that this would sustain. With the operator this would almost certainly be a terminal incident if face to face with the device. In the event of the device being inside a building then the collapse of the building should be considered and within that the potential loss of any machinery either manned or RC and the risk to the machine operator, and any collateral damage that would be sustained, adjoining buildings etc.

Risk assessment would always be the first instance, either dynamically onsite, or a pre-planned operation. An example of dynamically would be a search team carrying out clearance in an area and routinely finding simple non-complex devices, having a search advisory and an IEDD onsite and the manual disruption of devices being a planned part of the operation.

A pre-planned operation would be as a result of a complex device which needs further thought or investigation, or, there is a risk of large-scale collateral damage and permissions etc would have to be sought from local government agencies.

The condition of the device upon commencement of removal should also be considered. If a device was wholly lifted from the ground it may still remain a viable device and what is the process after that? It may be that scoops of rubble are being placed into armoured tippers or a rubble separation machine and that a device is unknowingly within the rubble, this could result in a low or a high order detonation at any stage and these risks should be considered, area reduction may well have been carried out on this area i.e. K9's but they are not a guarantee of the lack of presence of devices.

A known device would have to be examined by an IEDD operator who may elect to sever the detonating train to some degree to ensure that that risk is lowered but the risk of a secondary hidden trigger or means of initiation cannot be ruled out, if device has to be examined to such a degree that excavation takes place to ensure that the device is safe to be removed then this almost negates the need for mechanical removal.

NEQ is a difficult question to answer, in the case of a landmine such as a TM-46, this is a soviet mine containing 5.7kg of TNT. The behaviour and capabilities of TNT are well known

and predictable. An IED is likely to have an explosive fill of unknown origin and capabilities, its behaviour cannot be predicted and different types of HME have different capabilities, this means that a common size NEQ would have to be agreed on and the lower end of the scale be set as a standard, the size of the machine would also be a factor in this. To the best of my knowledge there is an NEQ of 8kg in place with M## (authors amendment) in Syria Mechanical clearance should never be considered where manual search teams are in close proximity, an example would be plant equipment working in the grounds of an in close proximity of a building and teams inside the building. Should the plant either damage a supporting wall or function a device that would damage the structure it may then cause a partial or complete collapse with teams in the building. It should never be considered where the collateral damage would be too great, an example of this would be inside an oil field and affixed to storage tanks etc. Such an item would have to manually dealt with. Devices inside fuel stations have been dealt with, the collateral damage here is obvious, all these devices have been manually dealt with.

Lastly, if the device is considered so large that the main charge would cause catastrophic damage to the machine or its human operator then manual disruption would be carried out.

**Question 7.**

**Answer**

This in theory should be a fairly simple answer but social nuances, corruption, and ineptitude make it a very difficult process.

The theory-

The NMAA will be the focal point of all demining operations within the country. Other governmental agencies will pass on clearance requests to the NMAA, local populace can go to the mayor's (or similar) office and request clearance, the mayor will pass these to the NMAA. Individual requests can also go to the NMAA who will then categorise and prioritise the request and task the relevant body to do the task.

Iraq for instance has decreed that NGO's and commercial companies will work on infrastructure taskings such as schools, healthcare, power and water etc, all infrastructure taskings that will kickstart and assist the "normalisation" process immediately post conflict. Iraq has also decreed that humanitarian clearance such as fields, farms, housing etc will be carried out by national security forces such as the army and the ministry of interior.

It is the task of the NMAA to decide if the task is a high or low threat task and whether it is humanitarian or infrastructure and then create a Tasking Order (TO) and issue it to the actioning agency who will then complete the task and associated paperwork for The Information Management System for Mine Action (IMMSMA) and submit this back up the chain for processing.

The reality-

I use Iraq as a reference because the depth of my experience is there. Before the NMAA in Iraq, in this case the Demining Agency (DMA) decreed that it wold be the focal point for clearance operations then local agencies could apply to the UN who would then pass it on to UNMAS who would then task teams within their own AOR, this system worked fairly well dependant on who was in the chair at UNMAS. Requests would come in from local agencies that were outside the remit of infrastructure UNMAS would refer these back to the originator or to the DMA for tasking.

When the DMA took control of tasking then the flow of TO's dried up and DMA failed to produce them, or as was feared TO's would be produced that did not fit the profile of the organisation tasked and clearly baksheesh was a factor in TO's being produced and the TO's being produced by personnel in office who are not necessarily qualified or have an understanding of the requirements of the office the hold ( I know you wont believe this but its true!)

In a nutshell what this leads to is clearance companies self-generating work, often with a lip service passing of the task to the DMA who would tacitly agree to the task but fail to produce a TO for the task, the clearance company carrying out the task and all IMMSMA paperwork as normal, the next flaw in the plan is the IMMSMA paperwork not being filed correctly by national mine action agencies who are responsible for the mapping and issuing of hazard/cleared areas, they are either not competent or cannot manage the weight of the information coming in. This can mean that cleared areas are still marked as hazardous or confirmed hazardous areas not being recorded and mapped.

To address the considerations above-

- Clearance organisations are by far the subject matter experts rather than NMAA staff and the opinion and advice should be listened to for that reason but the subject should be managed without the appearance of the tail wagging the dog so to speak as this may upset the social nuances of middle eastern culture. Crossing the NMAA can result in such things as accreditation being withdrawn and work stopping as a result of this.
- Advice to NMAA, again without wanting to create an atmosphere of the tail wagging the dog, the NMAA should be included in everything, albeit all the work done for them but at least sow the seed of the plan with the NMAA and let them put it back to you as their idea, this is often very time consuming with very little forward progress, it may be that clearance companies made up of largely former western army personnel expect western army standards from everyone and expectations have to be managed to accommodate the NMAA pace. Advice to HMAA should be gentle subtle steerage towards the desired task and let them work their own plan into it.
- Flaws in system- as above.

**Question 8.**

**Answer**

Mechanical removal would never go ahead without being involved in a search and clearance process so to that end the relationship between searchers and mechanical equipment is a symbiotic one.

To that end training should first focus on the skills and requirements of each actor and then build up into interdepartmental training so that each aspect of the operation knows what is required of them, what the capabilities and limitations of each other is, and how each aspect should conduct themselves during operations.

To that end searchers should be involved at every step whilst trying to manage the risk of searchers thinking themselves some sort of SME in mechanical clearance when their role is detector swinging within in a team.

Training would depend on the quality and history of the searchers or the company involved. If they are first time employees within the industry then it would be something like a 3 week programme to turn them into low threat BAC operators, then maybe another fortnight to upskill to high threat search teams, concurrent mechanical training could take place with a final week of confirmation training involving all departments acting out their role.

Employing a company already skilled in such matters would expedite the training because it may only involve upskilling and training to company SOP's before accrediting.

**Role**: MB. Senior Operations Manager **Operational Experience**: 20+ years

Just as a bit of an overview, I have worked in numerous projects with mechanical assets used in the locating and removal of explosive devices. (Cambodia, Angola, Zimbabwe, Afghanistan, Iraq, Syria, Sri Lanka). Whilst the threat may be known mines or ERW. The threat of IEDs can generally not be dismissed. A lot depends on high or what is classed as an IED.

When considering the suitability of machines within in an ERW threat, some effort should be made to determine what threat has prevalence. Is it the switches or means of initiation, or is it the explosive threat, size of potential charge, primary fragmentation, secondary fragmentation. The role and type of machine to be used.

Remotely operated machine, aimed at disruption and avoidance of detonations or Operated machines. Are detonations acceptable if so what level of damage is acceptable to the machine.

Ultimately all the machines in use aim to reduce the risks to personnel, through stand off and/or protection.

**Question 1.**

**Answer**

In my experience it depends on the machine in use. For example the Syria project had a mix of bespoke and commercial off the shelf (COTs). The end user will tend to adapt machinery

or procedures to meet there needs. As a result I'd say that the situation influences how machines evolve within the project.

Bespoke machines are developed through a mix of what a manufacturer feels is needed, or evolution of exiting machine ideas and new technologies and materials. In Syria the mini robot follows basic military design. The Armtrac a larger machine was adapted from a Demining design, reduced in size and with an additional opportunity to add rear tools. However the COTs systems were completely developed by the project, machine selection was heavily influenced by the budget but more by the availability of suitable machines locally. The same situation was also the case in other projects I have used COTs. There are some guidance documents on what is deemed suitable armouring.

As the Operations Manager I was able to have input in the selection of the machines. Feedback to management is given as required and where requested. Likewise feedback is also provided to manufacturers. This is generally informal and not as a structured Test and Evaluation report.

All machines require supporting, be that simple modular spares packages (ie robots) or more complex machines requiring a full workshop, transport vehicles, fuel, etc. These need to be planned through whole project life cycle.

**Question 2.**

**Answer**

Ideally there should be test and acceptance before the machine and operators are deployed to live tasks. In Syria this was carried out locally at local level. It formed part of the quality management system (3 step process).

I don't believe subjecting machines to detonations will add "significant" value. To add value the machine or implements would have to tested to destruction to determine provide guidance on maximum failure limits. However, once Operational the environment and threat cannot be assured. The exception would arguably be using a robot to conduct remote RSPs on a confirmed and isolated device.

Emphasis needs to ensure that a credible, auditable and transparent regime of test and evaluation of procedures and methodology and application testing

**Question 3.**

**Answer**

Machines and modifications do occur to machines – examples seen include

Armouring,

Rotation of buckets to push away rather than pull (excavators)

Fitting of camera systems – that enabled the operator of the machine and the site manager to view what is happening.

Design and development of weapons (disrupter)

Buckets, blades, hoist,  to the Armtrac

Engine mods to hydraulics

Battering rams

Some limited testing was carried out on armoured steel,

Tools were tested in test areas and during operator training.

SOPs were developed before deployment and operators trained

**Question 4**.

**Answer**

Remote observation is ideally required after the positive action, this was achieved by UAS (drone). Remote cameras on the machines… robot, Armtrac, excavators, even RC cars with GoPro

All efforts should be utilised before any manual approach

**Question 5.**

**Answer**

Yes this is the general TTPS in place though terminology may differ.

This is an operational structure. (No operational structure was included – Authors note).

**Question 6.**

**Answer**

Safety of the approach and access

Environment

Nature of the means of initiation – VO, RC etc.

Number of means of initiation

Type of charge, blast, DFC, Frag

Size of charge

**Question 7.**

**Answer**

In Syria we as the Clearance organisation has autonomy on the actual task although the client defined the task types and provided some target data. The operator must have right of refusal and access to appropriate tools.

In Iraq it is well known that operators do not and are prevented access to necessary explosives, IEDD weapons, remote options should be available to organisations to reduce the risk to operators and personnel.

**Question 8.**

**Answer**

In the ideal environment all personnel should receive appropriate training.

Operators generally have training that focuses on operating and maintenance with some ERW awareness.

TFMs and TLs need training on the employment of the systems, command and control, managing evacuation.
Ops Mgrs – need training on machine limitations and capabilities, managing efficiency, log, admin.
Searchers need to be trained in roles and hazards they may have in supporting the machines.
All should be trained on the potential hazards associated with the use each machine.

**Role**: JC. Senior Operations Manager **Operational Experience**: 20+ years

**Question 1.**

**Answer**

The IED remote removal machinery is primarily driven by the “end user”, however some companies have taken it upon themselves to hire their own subject matter experts, in an effort to enhance this machines and capabilities, making them more attractive to potential buyers. This has improved the quality and capabilities of the machines when purchased off the shelf. It is impossible to foresee all aspects and environment of clearance and the IED threat and produce a machine that can fulfil the role off the shelf.
Depending on the clearance organisations structure and contractual arrangements with manufactures of these machines affects the selection process for the assets. It has been seen to be cost and affiliation driven within the clearance industry. This leads to not always having the right machine for the job. In cases like this there is a lot of “in house modification” to the tools and machines to make them better suited to the clearance organisations known threat and environment. It has been my experience that the clearance organisations inform the manufacture of the machines of their “in house modifications” with some technical specifications. This exchange of information helps with the R&D of the machines and to ensure that the machine itself can structurally handle the new tool or modification.
With these “in house modification” happening on a regular basis it is essential that the clearance organisation have a fully stocked and manned fabrication workshop located somewhere within the project. There must be a well-managed logistical supply chain in place to facilitate such modifications and maintenance.

**Question 2.**

**Answer**

Yes, there should definitely be a “test and acceptance protocol” for such machines as with all demining and clearance tools. It should be an industry standard with guidelines from outside the manufactures control.
Some of the points that should be test are, but not limited too;

- Daily operating costs
- Required daily maintenance hours against operational hours

- Minimum requirements to transport the machine from task to task
- Ease of purchase off the shelf replacement parts and components
- Manufactures hostile environment logistical support abilities
- Manufactures technical support to field mechanics and the availability of this support
- Manufactures ability and willingness to train clearance organisations staff to “train the trainer” levels
- Operational distance of operator remote control, within a steel reinforced concrete structure
- Visibility of operations through machine mounted camera systems
- Operational distance of camera signal from machine within and steel reinforced concrete structure
- The ability to mount ECM on the machine
- Self-recovery with the machine should there be a mechanical failure (i.e., independent electric winch)
- Blast survivability at the manipulator arm tool. (5kg)
- Ability to “up armour” machine with either hard or soft armour

**Question 3.**

**Answer**

Modifications are made to tools and machines by all clearance organisations, this occurs based on the threat faced and the environment of operations. It is not possible to foresee or predict what or how the terrorist/insurgent will manufacture or use IEDs in each country without first-hand experience. The manufactures do their best to do this, but it is a physical impossibility, hence the modifications. Some manufactures will use this information fed back to them as a start point for R&D.

Some locally manufactured tools are as simple as a rake made to suit the size and dimensions of found IEDs. The addition of cameras to the machine permitting better all-round vision with structures is common. All modifications are based on unknown threat and operational environment.

**Question 4**.

**Answer**

The remote machine cannot fully finish an RSP, they do not have the correct manipulation at the tools, for example; to shunt and shield electric detonator wires. The machines remove the risk to life by creating standoff from the IED for both machine operator and IEDD operator during the separation IED components. The RSP is only complete when an IEDD operator has carried out all aspects of RSP and has physically confirmed this him/herself. After the machine has made such separation of components it is possible to use a second machine/tool to observe this before the IEDD operator moves forward to RSP the device,

only after observing the appropriated soak time IAW SOPs. This precludes searchers and K9 from going forward as only a current and validated IEDD operator is capable of the RSP.

**Question 5.**

**Answer**

Nothing to add to this, the above is extremely close to the current proven methodologies.

**Question 6.**

**Answer**

Once an IED has been detected through a search, it can be assessed for the correct method of disposal, at this time it can be determent is mechanical means are warranted.

Some considerations at this point, but not limited to are;

- Machine accessibility
- Suitable tools for the manipulator arm
- Correct safety distances with remote means
- Lifting capacity against the estimated overall weight of IED once component separation has been achieved.

It should be remembered that all remote machines in the IEDD environment are “sacrificial” tools and are there to reduce or eliminate risk to life.

Machines should not be considered if their presence will have a negative effect on the surroundings and structures and would cause additional unwarranted damage.

**Question 7.**

**Answer**

There are many contributing factors to the tasking of clearance sites, HNMAA is definitely one of them as they serve the national interest for the most part. The biggest flaw with HNMAA is that they can be self-serving, wanting sites cleared that should not be prioritised as urgent.

The contracts the clearance organisations have with their clients/donors has a major part in it. Depending on what the client wants to achieve will depend on what sites the clearance organisations will take on. Another factor is the actual clearance capabilities the organisation has. Some sites may be beyond their abilities and should be avoided.

**Question 8.**

**Answer**

The machines themselves are capable of much more than just IED work, this means that all aspects of their capabilities should be taught to the machine operators. TFMs and TLs should not be trained on the machines unless the clearance organisations SOPs state that the operator must be IEDD qualified, the TFM/TLs have far too many things to be managing on the task site to have to run and maintain a machine.

The machine operators should as a minimum have the following training (in house)

- Basic IED component awareness
- Basic UXO awareness
- Machine operations (minimum 2 weeks training)
- Machine maintenance (daily)
- Clearance organisation SOPs related to machine operations and IEDD/CIED

The machine training should be delivered by either the manufacturer's training team of a qualified trainer that has been certified by the manufacturer. For both operators and mechanics, a like. The EOD training must be delivered by qualified EOD/IED operator.

**Role**: GH. Technical Field Manager **Operational Experience**: 20+ years

**Question 1.**

**Answer**

The machines that are available are fairly limited in their capacity to conduct IED clearance in buildings that have suffered extensive damage through bombing. A trained operator (No2) should be dedicated to the use of the machine with the guidance from the (No1). There must be a capacity in place to service and maintain any machines that are used. Not just from detonations but also daily wear and tear. Each machine will differ slightly in its operation.

**Question 2.**

**Answer**

The detonation from an IED can be as little as 500 grams or up to 10kg depending on the type of IED. The point of Impact (POI) would be which ever part of the machine disturbs the IED and functions the switch, be it a flail, roller or track.

**Question 3.**

**Answer**

Modifications are generally conducted to allow the operator to have a clearer perspective through his (or her) cameras. Typically a weapon such as a pig stick would have tape added to the end of the barrel to let the operator know when he is on target.

**Question 4**.

NO, a K9 or search team member should never carry out QA once an RSP has been conducted. It will always be the number 1 operator who confirms, or if a remote ROV is available then this would go down range 1st and scope the area with its cameras to try and ID all the component parts.

**Question 5.**

The correct sequence of events are listed above. The **Discover** phase can also be by a direct search from a trained search team

**Question 6.**

**Answer**

This is a very difficult question to answer as every situation will be different. If we are dealing with know patterns of IED belts for an area denial then the type and size of IED will be determined at the beginning and if a suitable machine is available then this will be used.

**Question 7.**

**Answer**

The tasking authority, who ever it may be, **must** have all the information to hand as areas are cleared systematically. This information should be available to all involved in clearance operations.

**Question 8.**

**Answer**

When ever A new piece of equipment is introduced to any organisation then extensive training must take place on that equipment so everyone is fully conversant with it. It will be situation dependent as to whether searcher will also be included in the training. The length of training will be dependant on the people being taught and there capacity to take in and retain information.

**Role**: AE. Team Leader **Operational Experience**: 10- years

**Question 1.**

**Answer**

End user led. The originator does have influence over the inclusion of modifications to the extent that the machine will still be able to operate effectively as designed. The selection of the machine is based on the needs of the end user and Feedback on effectiveness is provided regularly to line managers. Currently we are using modified commercial machinery with in country maintenance support however all modifications are end user fabricated and fitted with originator approval.

**Question 2.**

**Answer**

Yes, IED's generally have a much larger NEQ and increased fragmentation. (Especially DFC's) Therefore to ensure the safety of the operator, ballistic glass/armour plates should be tested to a range similar to the threats being targeted in the end users locality.

**Question 3.**

**Answer**

Yes. Fabrication of specialty tools enhances the ability of clearance team to overcome specific challenges on site. E.g in an urban environment a "door knocker' was fabricated to facilitate remote entry into structures. A large I-beam approximately 6m long welded to a frame that then attached to the top of a front-end loader bucket. This provided considerable safety distance for the operator with the mechanical arm fully extended plus am additional 6m standoff distance. This idea came from a discussion with a mechanical manager about

challenges teams were facing in the field and possible solutions to this specific threat. The fabricated attachment was then deployed with the mechanical asset as it conducted its normal activities. The new attachment was then tested on a safe structure to gauge it's effectiveness.

**Question 4**.

**Answer**

QA must be done by a search team/operator as the operator is the only one who can declare an RSP successful or conduct remedial activities if the RSP has failed. Additionally, if the explosive content has been spread in the area a K9 will have difficulty pinpointing exact locations of explosive devices.

**Question 5.**

**Answer**

Yes & No. **Discover-** places too much emphasis on the reliance of outside information. While gathering information from local sources can be of some benefit no one should take this information as gospel. Every operator should read and assess the ground as they see it, this prevents accidents from either expecting or not expecting something to be there.

**Detect-** Search is conducted of CHA's not SHA's.

The rest of the points are acceptable.

**Question 6.**

**Answer**

Size and type of charge e.g. DFC & EFP would be especially dangerous as they are designed to penetrate armour, and the overpressure from a large charge can defeat the armour altogether. Type of Switch e.g. Crush switch are hyper-sensitive, PIR are obviously to dangerous to approach etc.

**Question 7.**

Yes, clearance organisations should have influence into their own tasking. This could allow greater control and smoother transition in the clearance process

**Question 8.**

**Answer**

Training should be conducted with guidance from both TFM and Mechanical TFM to ensure all needs of the search team can be met while ensuring the mechanical assets operate within safe parameters.

Mechanical operators should practice removing appropriate devices safely. This will give confidence to the operator, TFM and the Mech TFM.

**Written interviews end**

## APPENDIX 9 - THEMATIC PILLARS

### (9.1) Key Words and Phrases

Key words and phrases in respondent's answers were identified using the author's experiential knowledge as significant by their use, frequency or meaning. These key words and phrases were then grouped together into thematic pillars.

**Table 2. Key Words and Phrases.**

| Written Interview Key Words and Phrases | | | | | | |
|---|---|---|---|---|---|---|
| **Machinery Modification** | **Testing and Acceptance** | **Safe Working Practices** | **Tasking Procedure** | **Financial Considerations** | **Operational Support** | **Mechanical IED Removal Training** |
| modification , remote control, camera, ECM, rakes, input from end user, commercially modified, bespoke, lifting arm, detection equipment, prior experience, adaptions of | Blast survivability, up armour, threat faced, sacrificial, NEQ, manufacturer rating, sacrificial machine, tested, stand off, NEQ limit, machine tested to, data provided by other | Threat and risk, risk assessment, threat assessment, IED context, SOP's, operator safety, task relevant, sharing information, actions on, high risk environment, intentional or un- | Timing, restrictions, information led, poor manning and staffing, tasking systems, complicated & lengthy, incorrectly employed staff, geographical location, hijacked | Cost, operating cost, practicable, approved, operation structures, financial implications, tool box approach, capability, limitations, what/where used, current | Maintenance, logistical support, technical support, self recovery, field repair, movement of equipment, servicing, properly trained individual/department, qualified and experienced Mech TFM, transport and recovery of selected | Training, certified, qualified, suitably skilled, operators dual trained, operate and repair, not necessarily have the correct experience or training, machine operation |

| Written Interview Key Words and Phrases | | | | | | |
|---|---|---|---|---|---|---|
| **Machinery Modification** | **Testing and Acceptance** | **Safe Working Practices** | **Tasking Procedure** | **Financial Considerations** | **Operational Support** | **Mechanical IED Removal Training** |
| proven devices, ballistic glass, Tactical level Modifications, improve, operational use, buckets & flails, extra anchorage points, override to the hydraulic system, aid recovery, sanctioned and rectified. temporary modifications, ceramic blades, adapt to the ever-changing environment. | Industry service providers, inspected prior to its use, | intentional detonations, unknown factor of explosive, good safe working practices, threat area, local threat, safe lifting, safety and suitability, human factor, Quality Control, explosive safety, see the Threat, Search Restrictions. | (system), access, intelligence, good surveillance system, management and control, Pre-Plan Operation, shutting down the networks, Non-Technical Survey, Implementation Plan, completion report, simple spot task, critical infrastructure, | funding, Donor, contract requirements, lack funding, electronic structure, several depts, lengthy, speed up, cost implications, budgetary constraints, procurement process, | machine, good workshop facilities, local needs, Service and support, spares and maintenance, local skills suitable to conduct technical repairs, overhaul, machine ORK log, | practical trg & assessment, 4-6 weeks, skill set is available, basic knowledge, compliant with SOPs, enhance performance and to increase safety, skills level of operators, SME to deliver training, offer technical advice, introduction to Mechanised Assets, |

### (9.2) Focused Topics

These key words and phrases were synthesized by the author and focused into topics which concentrated the key words and phrases into descriptive activities that could be developed into best practice guidance to clearance organizations.

**Table 3. Focused Topics**

| Focused Topics | | | | | | |
|---|---|---|---|---|---|---|
| **Machinery Modification** | **Testing and Acceptance** | **Safe Working Practices** | **Tasking Procedure** | **Financial Considerations** | **Operational Support** | **Mechanical IED Removal Training** |
| 1. Modification of IED removal machinery for tools and protection may be required to suit the need of organization.<br>2. End user input into modifications and manufacturer | 1. Pre-inspection of IED removal equipment, modifications and tools is required for quality control and suitability.<br>2. Survivability of personnel is paramount, survivability of IED removal | 1. Risk assessments must be carried out for all operations.<br>2. Threat assessments must be carried out on all tasks.<br>3. Standard operating procedures must | 1. Intelligence led tasking from the home nation mine action authority is required by clearance organizations.<br>2. Good command and control exhibited by the tasking organization | 1. Donor, contract requirements must be considered when procuring IED removal machinery.<br>2. The procurement process should include consideration of | 1. Maintenance support for IED removal machines should be a pre-requisite of mechanical IED removal operations.<br>2. Logistical support to IED removal machines should be considered when project planning. | 1. Training must be certified as being delivered by a competent person or organization.<br>2. All operational personnel must be qualified to perform their role.<br>3. All operational personnel should |

| | | | | | | |
|---|---|---|---|---|---|---|
| design is desirable.<br>3. Experience proven modifications to IED removal machinery and tools can add to local capability.<br>4. Increased capability of IED removal machinery is a desired outcome.<br>5. All modifications should be sanctioned, tested and approved IED removal machinery completed by an | machinery and tools is desirable.<br>3. IED removal machinery should be tested and assessed against known net explosive quantities.<br>4. Data collection from an established test and acceptance protocol should be widely disseminated within the industry. | be developed and practiced.<br>4. Safe working practices must be employed in all phases of operations.<br>5. Quality control must be carried out on all phases of the operation. | improves the clearance process.<br>3. A simple system for collation of information and tasking of clearance teams is required by clearance organizations.<br>4. Tasking organizations are encouraged to clearly define critical infrastructure and humanitarian infrastructure requirements.<br>5. Tasking organizations are | the whole of life employment of IED removal equipment.<br>3. The operating costs of IED removal equipment should be considered as part of the project financial risk assessment.<br>4. Changing budgetary constraints should be considered in the procurement process. | 3. Technical support from manufacturers should be encouraged to support clearance organizations deployed on operations.<br>4. A Mechanical Technical Field Manager should be considered as a key role to mechanical IED removal operations.<br>5. Operational Record Keeping is fundamental to the efficient maintenance and servicing of IED removal equipment. | be experienced to perform their role.<br>4. All training must be compliant with standard operational procedures and international standards.<br>5. A practical assessment of all operational personnel must be included as part of the training programme. |

| | | | | | | |
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| established test and acceptance protocol. | | | encouraged to use trained personnel for the process of collation and tasking clearance teams. | | | |

## APPENDIX 10 – Risk Assessment

**RISK ASSESSMENT GUIDANCE FOR MECHANICAL IED REMOVAL IN THE URBAN ENVIRONMENT.**

1. Is the task an official tasking from the recognized home nation mine action authority agreed by the project chain of command?
2. Is the source of any information about the IED reliable?
3. Has an IED threat assessment been completed?
4. Is the IED assessed to be victim operated? If the IED is assessed to be command wire or radio control activated then the task must be declined and must be referred back to the home nation mine action authority for further action.
5. What is the estimated net explosive (NEQ) quantity of the IED?
6. Does the NEQ exceed the test and acceptance protocol rating of the IED removal machine?
7. What is the assessed switch mechanism for detonating the IED?
8. Is the IED removal machine tool appropriate for the switch mechanism?
9. Have any modifications to the IED removal machine or tools been tested and approved?
10. Is the approach and method of transport to the task site secure and appropriate?
11. Is the task site suitable for mechanical operations?
12. Is there any critical infrastructure or humanitarian infrastructure that could be damaged in a high order detonation?
13. Are the standard operating procedures (SOP's) suitable for this task?
14. Have any variations to the SOP's been discussed and approved by the personnel involved in the task?
15. All personnel involved in the task correctly trained, suitably qualified, experienced and authorised to perform the task and their roles?
16. Is the IED removal machine correctly serviced, maintained and capable of the task?