ANALYSIS OF ALTERNATIVE CONVOY ROUTE PATROL PROCEDURES FOR COUNTERING IMPROVISED EXPLOSIVE DEVICES DEPLOYED DURING ASYMMETRIC WARFARE IN AFGHANISTAN-LIKE RURAL SETTINGS

by

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ABSTRACT

Improvised Explosive Devices (IEDs) are the greatest casualty producing and costly weapon system employed by the enemy on the asymmetric battlefield of today. Despite Billions of dollars spent on technological devices to counter the IED threat, IEDs are still responsible for roughly 50% of battlefield casualties. A tremendous amount of effort and resource has and continues to be levied in the pursuit of a technological solution to the IED problem. By contrast, little research has been done on Counter Improvised Explosive Device (CIED) procedures. This paper explores the potential of CIED procedures as a casualty reduction mechanism by comparing two observed tactical procedures used in patrolling convoy routes.

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LIST OF ACRONYMS

AJP- Allied Joint Publication

ARI - Army Research Institute

AtN- Attack the Network

CCW- Convention on Conventional Weapons

CERDEC- Communications Electronics Research Development and Engineering Center

CIED- Counter Improvised Explosive Device

COB- Civilian on the Battlefield

COP- Combat Outpost

DoDD- Department of Defense Directive

DtD- Defeat the Device

ECM- Electronic Countermeasures

EFP- Explosively Formed Penetrator

FLIR- Forward Looking Inferred

FM- Field Manual

FOB- Forward Operating Base

HSTL- Home Station Training Lanes

IED- Improvise Explosive device

IO- Information Operation

JCOE- Joint Center of Excellence

JIEDDO- Joint Improvised Explosive Device Defeat Organization

JIN- Joint IED Neutralizer

LOO- Line of Operation

LOS- Line of Sight

MCIT- Mobile Counter IED Trainer

MRAP- Mine Resistant Ambush Protective

MSR- Major Supply Route

NVESD- Night Vision and Electronic Sensors Directorate

OSD- Office of the Secretary of Defense

PDU- Protocol Data Unit

SME- Subject Matter Expert

TSE- Tactical Site Exploitation

TtF- Train the Force

VBIED- Vehicle borne improvised explosive device

CHAPTER ONE: MOTIVATION FOR RESEARCH

Introduction

Improvised Explosive Devices (IEDs) account for more casualties and wounded on today's battlefield than any other single weapon system accounting for over 50% of casualties in Afghanistan (Wilson, 2007). IEDs are the weapon of choice of insurgent and guerrilla forces. This weapon system has had a prolific effect on Armed Forces across the globe. The U.S. alone has spent in excess of 75 billion dollars on armored vehicles and technologies designed to mitigate or defeat the effects of the IED (Zoroya, 2013). This amount exceeds the total annual military expenditure for 2014 of all but four of the world's military services (Perlo-Freeman, Fleurant, Wezeman, & Wezeman, 2015). Despite the amount of money and technological innovation, and saturation of technology on the battlefield with the creation of the Joint Improvised Explosive Device Defeat Organization (JIEDDO) in 2006, casualty rates peaked in 2010-2011, as troop levels saw a reduction at the end of 2011; IED casualties also saw a similar reduction in number. Recently, the White House and Department of Defense DoD have identified IEDs as an enduring threat that will continue to play a role in future conflicts (Obama, 2013).

The purpose of this chapter is to highlight the importance and concern of the IED on today's battlefield and to lay a foundation for potential solution. U.S. Counter Improvised Explosive Device (CIED) efforts focus mainly on addressing the issue with technological innovations (Cary & Youssef, 2011 updated 2014). The vast majority of the estimated 75 billion dollars the U.S. has spent on CIED over the last decade has been on new equipment and technology (JIEDDO, 2008, 2009, 2011). The threat of the IED is not going to disappear however; the amount of resources to combat the problem shall be seriously constrained relative to recent expenditure, as budgets become increasingly smaller. JIEDDO for example has already started to execute a plan to reduce its personnel from a peak of 3,900 to 400 by 2017 (Weisgerber, 2013). Given the budgetary constraints, a look into past solutions as well as current methodologies employed by less technologically equipped forces may yield a sustainable CIED approach as well as providing the tools to reduce casualties. In an effort to keep this paper unclassified, sources used in this paper are all freely available and unrestricted.

Definitions

Two definitions are important in understanding what an IED is as well as understanding the developments that led to the IED problem. The two definitions are the current definition of an IED as defined by field manual (FM) 3-31.8 and the definition of a booby trap as defined by FM 5-31 which became obsolete in 1980. FM 5-31 is an important document, as it allows a comparison between current insurgency operations and doctrine used by the U.S. Army prior to 1980.

FM 3-21.8 The Infantry Rifle Platoon and Squad defines and IED as:

> "A nonstandard explosive device used to target U.S. Soldiers, civilians, NGOs, and government agencies. IEDs range from crude homemade explosives to extremely intricate remote-controlled devices. The devices are used to instill fear in U.S. Soldiers, coalition forces, and the local civilian population. Their employment is intended to diminish U.S. national resolve with mounting casualties. The sophistication and range of IEDs continue to increase as technology continues to improve and as terrorists gain experience."

While the definition indicates that IEDs are becoming more sophisticated they are not by any means a new threat (*FM 3-21.10 The Infantry Rifle Company*, 2006). FM 3-21.8 further defines three IED types as “timed explosive devices”, “impact detonated devices”, and “vehicle bombs” or vehicle borne improvised explosive device (VBIED).

> “Time explosive device is any IED that is detonated by remote control such as by the ring of a cell phone; by other electronic means; or by the combination of wire and either a power source or timed fuse” (*FM 3-21.10 The Infantry Rifle Company*, 2006, pp. G-1).

> “Vehicle bombs include explosive-laden vehicles detonated with electronic command wire or wireless remote control, or with timed devices. They might be deployed with or without drivers” (*FM 3-21.10 The Infantry Rifle Company*, 2006, pp. G-1)

FM 5-31 Booby Traps defines a booby trap as an:

> “Explosive charge cunningly contrived to be fired by an unsuspecting person who disturbs an apparently harmless object or performs a presumably safe act. Two types are in use: improvised and manufactured. Improvised booby traps are assembled from specially provided materially generally used for other purposes. Manufactured booby-traps are dirty trick devices made at a factory for issue to troops. They usually imitate some object or article that has souvenir appeal or may be used by the target to advantage”.

Historical Background

The term IED is relatively new and arose from the British military in describing tactics and actions by the Irish Republican Army in the 1970s (Benson, 2012). Despite some of the popular belief that IEDs are a new weapon from the conflicts in Iraq and Afghanistan, improvised explosive devices or commonly known as booby traps have been present on the battlefield for centuries. Many purposely manufactured fused switches and ignition systems were developed and employed during WWI (Jones, 2004). By WWII every major power actually manufactured booby traps and/or components for use in improvised explosives (*FM 5-31 Boobytraps*, 1965). The National Archives is chocked full of video footage of “booby trap” and mine neutralization in WWII, Korea, and Vietnam. In WWII, the War Department found improvised explosives such a nuisance that they created a cartoon series “Private SNAFU” in an effort to teach soldiers about the dangers of the battlefield, booby traps, and souvenir scavenging. While filmed in the 1940s their message is no less relevant today; many of the videos subjects such as booby traps, and information leakage are still relevant on today’s modern battlefield (Archives, 1943). .

One may be surprised to find that the U.S. Army viewed IEDs or “booby traps” as a battlefield enabler until 1980, while never widely used by U.S. forces in conflicts, use of such devices practically stopped with the signing of the Convention on Conventional Weapons (CCW). The CCW limited the use of fragmentation weapons, landmines, booby traps, incendiary weapons, and blinding laser weapons (Nations, 1980) . Several obsolete Army manuals are freely available on the internet and reputable sources such as amazon. The now “obsolete” manuals cover the doctrine, manufacture, and employment procedures for booby traps, improvised munitions, and incendiaries. Three relevant manuals are FM 5-31, TM 31-210, and TM 31-210-1. FM 5-31 “Booby Traps” covered the doctrine, use, manufacture, and employment procedures for booby traps on the battlefield. TM 31-210 Improvised Munitions Handbook covers the process to manufacture explosive materials out of common locally sourced materials. Finally, TM 31-210-1 Incendiaries covered the use of both conventional and improvised incendiary devices. Though not widely used by conventional units, the use of booby traps could be authorized by division commanders, however higher level commanders could rescind the authorization of use at any time (*FM 5-31 Boobytraps*, 1965). Current policy restricts U.S. troops from using booby traps and incendiaries however, a Corps commander can authorize their use when deployment is in accordance with international law. .

How does the investigation into “obsolete” manuals benefit the soldier on the battlefield today? Quite simply put, insurgents use many of the devices, explosive materials, and ignition methods described in detail within these manuals. One example of a device described in detail with in FM 5-31, is the pressure cooker “booby trap” or now referred to as pressure cooker IED. This design appears across the globe on both the battlefield and in domestic attacks. The most recent well-known domestic attack of this type of device was the Boston Marathon bombing. Figure 1 depicts the illustration of the pressure cooker “booby trap” next to the post blast evidence from the pressure cooker “bomb” used in the Boston Marathon attack. The insurgents in Afghanistan and Iraq employ similar devices (Sisk, 2013). The largest difference between the two devices is the initiation mechanism; the Boston bomb utilized an electronic timing mechanism instead of a mechanical push/pull initiation(*FM 5-31 Boobytraps*, 1965; Parascadola, 2013). The overall design however differs very little.

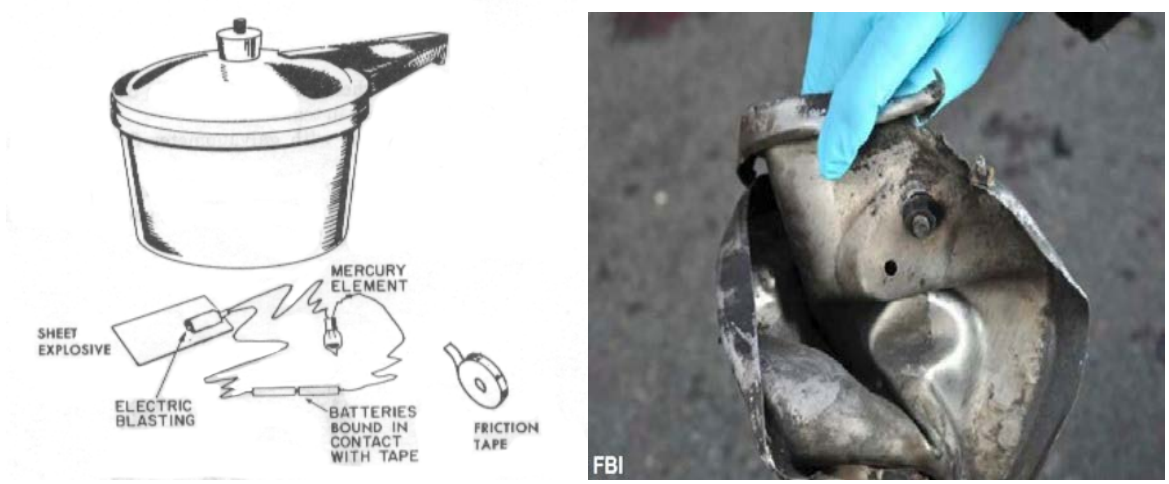

Figure 1: Pressure Cooker IED

FM 5-31 also illustrates and instructs on the construction of the explosively formed penetrator (EFP), one of the most devastating IEDs currently on the battlefield in terms of relative damage (Cockburn, 2007). EFPs are particularly successful when they hit their target. The aimed IED on detonation forms a directional shape charge, essentially a molten spear like slug that is able to punch through most armor (Garaux, 2009). EFPs cause extensive damage against coalition vehicles in Iraq, but only make up a small percentage of all IED attacks. The estimated cost of one of these weapons is only 20-30 dollars (Cockburn, 2007).

These manuals illustrate one of the continued problems the U.S. military has faced over the time, knowledge management. Despite fighting several insurgencies and gaining valuable knowledge on counter insurgency and guerrilla warfare, at it the wars conclusion, the focus on training typically reverts to the next conventional force on force war. The military slowly neglects the valuable knowledge it gained from the previous conflicts in which it had to fight an insurgency and begins fighting the next one unprepared (Ucko, 2009, p. 26). While FM 34.210 Explosive Hazard Operations refers to booby traps, it covers them in six pages, very different from the 130 pages found in FM 5-31. This would indicate that Training and Doctrine Command view booby traps as less of a priority than previous periods. As such, many of the skills and expertise needed to detect and defeat IEDs had to be re-learned when encountered in the latest conflicts.

The biggest difference between the technologies from 50+ years ago and today concerning IEDs and booby traps are initiation methods, improvised solutions of today replaced many of the once prevalently manufactured switches and fuses found in previous conflicts (Jones, 2004, p. 259). While the methods and doctrine of the past are still present and employed, technology has ushered in an era of the wireless remote command detonated device, cell phones and other wireless technologies have enabled more control over IEDs and booby traps than ever before. Digital timing circuitry also brings a level of sophistication and accuracy that is not available in chemical based timing fuses. Sophistication and adaptation usher in challenges in countering these new initiation methods.

Pursuit of CIED Technology

To counter the IED threat the U.S. has been pouring money into technological methods to counter the IED. Most of the technologies focus on defeating the device or force protection. Of the 75 billion spent on CIED thus far nearly two thirds has been on force protection in the form of the Mine Resistant Ambush Protective (MRAP) vehicle. Currently there are over 1800 initiatives in technologies for CIED under JIEDDOs watch (Martin et al., 2013). While there is no debate that the MRAP has saved lives, one can argue that the use of such equipment can impede mission sets. The vehicle itself being extraordinarily heavy can only traverse on certain roadways. Furthermore, 72% of the world's bridges cannot support the MRAP according to the Marine Corps assistant deputy commander for plans, policies, and operations (N. Defense, 2008). The use of the MRAP makes integrating with the population and COIN operations more difficult, as rural populations are sometimes un-reachable by the behemoth vehicles (Byford, 2010). With fewer route options available for travel it is far easier for the enemy to predict and strike with IEDs. Further, not creating patterns of travel that are predicable is problematic when using a vehicle that few roadways support.

The Non-Technological Approach

When looking for casualty reduction mechanisms to counter the effects of the IED, the U.S. may not be the ideal model. Many countries spend less on their entire annual military budgets as compared to the U.S. expenditure on CIED (Perlo-Freeman et al., 2015). As such, how have the coalition partners with a fraction of the budget the U.S. has approached the IED problem? The Romanian Army is an example of a less technologically equipped force. In Zabul Province, Afghanistan, Romanians operate M1152 Up-Armored Humvees, the very same vehicles in which the U.S. was rapidly replacing with MRAPs. They are equipped with an electronic countermeasure devices. These devices help protect patrols and convoys from remotely-detonated IEDs (Lockheed, 2011). Other than the electronic countermeasures, the equipment was the basic up-armored Humvee deemed inadequate and used by the U.S. prior to the rapid fielding of the MRAP.

The Romanian mission in Zabul Province focused on keeping Hwy 1 open and trafficable. Hwy 1 is a major highway ring circling Afghanistan that connects major cities together. It is an artery for trade and commerce for the nearly 300,000 residents in Zabul, as well as one of the few improved paved roads in the country (Partlow, 2010). Highway 1 bisects Zabul province and is a key section in connecting Kandahar to Kabul. The Hwy also supports both civilian traffic and large logistical convoys for coalition support coming from Pakistan moving to Kandahar. It is a major supply route (MSR). To accomplish their mission the Romanian forces conducted patrols and COIN operations with the villages that were near the highway from several forward operating bases (FOBs) and combat outpost (COPs).

Romanian forces in Afghanistan are an example of traditional doctrine utilized in CIED efforts. They patrolled a heavily IED infested sections of road, yet had considerably fewer casualties than U.S. Forces operating within the same province. Over the course of 2010 Romanian forces suffered six casualties to IEDs where as U.S. Forces suffered 21 to IEDs over the same time period (iCasualties.org, 2015).

Differences in observed outcomes between U.S. and Romanian forces raise a basic question. Why was a technologically less advanced force less prone to casualties at the hand of the IED than the technologically superior force?

Observation of several Romanian patrols as well as several U.S. Convoys and patrols yielded several observed differences in approaching the IED threat. While all coalition forces to include the United States follow a similar counter IED strategy as out lined in Allied Joint Publication (AJP) 3.15(B) (NATO, 2012), the basic patrolling techniques in particular, utilized and executed by the Romanians seem to have yielded better results. Romanian soldiers on patrols and convoys would stop and dismount soldiers to investigate all perceived danger areas. This included culverts, disturbed ground, new trash, anything that seemed out of place they would dismount four to six soldiers to visually inspect and clear the terrain prior to remounting and proceeding on the patrol. Their actions are basic doctrinal procedures covered under “Actions at danger areas (mounted)” found within FM 3-21.8 The Infantry Platoon and Squad(*FM 3-21.8 The Infantry Rifle Platoon and Squad*, 2007).

In contrast, U.S. Forces observed in convoys and patrols did not stop as frequently to investigate what the Romanians or doctrine considered a danger area, while this is too found within FM 3-21.8 it is a less cautious approach. It seemed the convoys instead choose to rely on their vehicular blast resistance as a countermeasure. The benefits of the Romanian, utilizing a more cautious posture ensures the route is quite rigorously screened for hazards resulting in temporary safe and clear route, but with the down side of slower patrol speed. Consistently stopping investigating all danger areas adds considerable amount of time to a patrol. Based on casualties the old adage “speed is security” many not hold true in the case of IEDs no matter how thick your armor.

Can something as simple as selection of movement posture, techniques, tactics and procedures lead to a drastic reduction in casualties? The Romanian selection of a cautionary movement posture, commensurate with the doctrine outlined in FM 3-21.8 producing relatively low casualty rates would seem to indicate this possibility. This research will explore the possibility of utilizing the clearance procedure within FM 3.21.8 soldier based visual search techniques as a potential mechanism for casualty reduction.

This chapter covered the problem of the IED, as well as the definitions of the IED and types of IEDs used. Highlighting historical examples of doctrine and knowledge of improvised munitions as well as some of the issues soldiers faced in previous conflicts. Finally, the motivation for reducing casualties introduced the research focus on comparing CIED procedures in an effort to reduce IED based casualties.

CHAPTER TWO: CIED LITERATURE REVIEW & IDENTIFICATION FOR NEEDED RESEARCH

JIEDDO

In 2006, after taking substantial casualties coupled with strategic and tactical loss to the IED, DOD Directive (DoDD) 2000.19E instituted the JIEDDO to coordinate DOD efforts in dealing with the continuing IED threat (*Department of Defense Directive 2000.19E*, 2006). JIEDDOs official mission defined in DoDD 2000.19E is as follows: “The JIEDDO shall focus (lead, advocate, coordinate) all Department of Defense actions in support of the Combatant Commanders’ and their respective Joint Task Forces’ efforts to defeat Improvised Explosive Devices as weapons of strategic influence” (*Department of Defense Directive 2000.19E*, 2006, p. 2). Figure 2 Illustrates the IED effects at the Strategic, Operational, and Tactical levels.

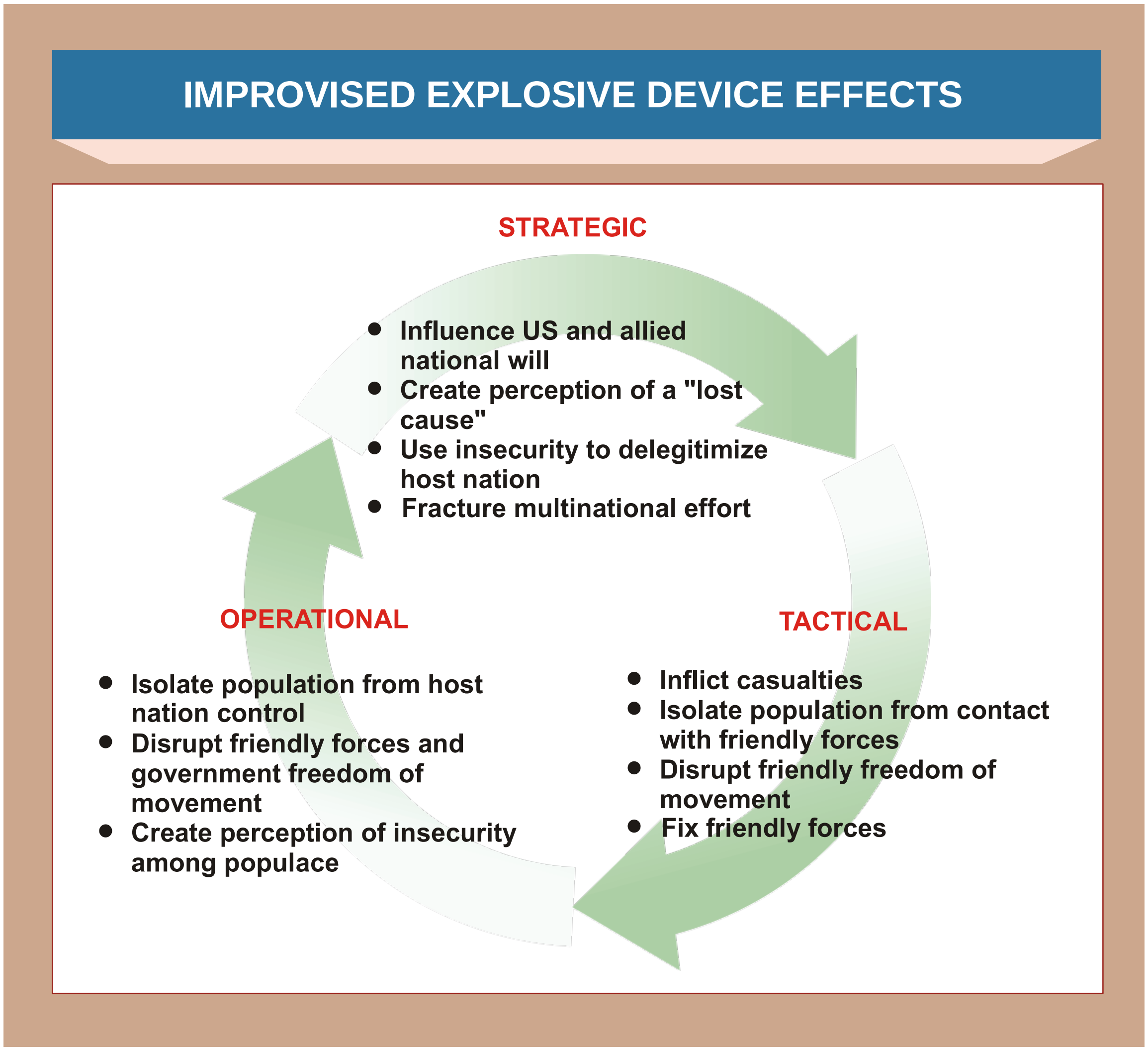

Figure 2: IED effects (JP 3-15.1: Counter-Improvised Explosive Device Operations, 2012)

The establishment of JIEDDO transforming a mere 12-person taskforce that tackled the CIED effort, into a three-star command overseeing, a 3900 person organization that immediately reported to the Office of the Secretary of Defense (OSD) injected bureaucratic hurdles in the fight (Ellis, Rogers, & Cochran, 2007; Weisgerber, 2013). Ellis notes that as JIEDDO ballooned into a large organization with multiple levels of management, one of the side effects of becoming a larger organization was a reduction in organizational agility in responding to battlefield changes and needs. Despite the organizational hurdles, JIEDDO's continued focus was on fielding technical equipment with the vast amount of resources going to DtD and AtN based initiatives (Ellis et al., 2007; JIEDDO, 2011).

The creation of this joint task force was in part an effort to stop parallel efforts by the different services, effectively wasting DoD resources by each branch of service producing parallel efforts in the fight against IEDs (Solis et al., 2010). Examples of parallel developments are the Counter-IED Electronic Counter Measure (ECM) systems, and MRAP development. Prior to JIEDDO, each service developed their own vehicular based jamming system as a result the DUKE (Army), ACORN, WARLOCK and CHAMELEON (Marine Corps) were all fielded. 14,000 jamming systems of various types were developed and deployed well after JIEDDO was established (Wilson, 2007).

Despite the focus of JIEDDO leading, advocating, and coordinating the CIED effort it does not have the authority to limit or stop on going acquisitions that may or may not be in line with the CIED fight (Carr, 2011). This lack of authority on JIEDDOs part will lead to continued parallel efforts tailored to the sponsoring services perceived need. As of 2011, a centralized database for CIED initiatives was yet to be established; however, efforts were ongoing to make such a database a reality in order to synchronize collective DOD wide CIED efforts (Solis, 2009).

This newly formed organization attacked the IED problem by establishing three lines of effort or lines of operation (LOO). The three LOOs are Attack the Network (AtN), Defeat the Device (DtD), and Train the Force (TtF). Theoretically, all of the lines contribute to the IED threat and are equal however; in terms of expenditure, AtN and DtD take the lion's share of the resources (JIEDDO, 2008, 2009, 2011). The focus of this paper resides mainly in the domains of

Defeat the Device and Train the Force. As the LOOs act as a three-legged stool, an AtN overview is also necessary to illustrate the effects of that LOO on the other two.

Attack the Network

AtN is the line of operation that targets the IED maker, financier, trainers, and other key infrastructure components critical to enabling the IED. In other words, AtN is an offensive set of operations that target the enemy's ability to resource, manufacture, and distribute (employ) IEDs. Disruption occurs by eliminating or limiting funding, controlling certain material goods used in the construction of IEDs such as fertilizer, neutralizing training experts, and key players within the network (JIEDDO, 2012).

To interdict in IED creation and employment on the battlefield, attacking the IED network on all levels is necessary. The easiest way to prevent an IED is to prevent its creation and subsequent employment (Garaux, 2009). In disrupting the network, a positive occurrence is the prevention of strategic victories for the enemy. For instance, if an MRAP strikes and IED but has no casualties with little damage done, it potentially remains a strategic victory for the enemy. The local populous sees the enemy as having the ability to strike at will against coalition forces and host nation forces, degrading confidence in their ability to protect them. Furthermore, the enemy in turn can use this attack as propaganda. If images of the attack are available, they are easily distributable across the internet for recruitment purposes as well as an attempt to erode the popular will in coalition countries.

AtN LOO focus is intelligence and collection platforms that enable targeting and disruption of the networks on the operational and tactical levels. Intelligence focuses are CIED intelligence, weapons technical intelligence, persistent surveillance, reconnaissance, information operations (IO), counter-bomber targeting, IED technical and forensic exploitation, and disposal of unexploded ordinance (Vane & Quantock, 2011). To assist in these focus areas the development of multiple aerial and terrestrial sensors have aided in building a common operating picture and allowing intelligence officers to track and target IED networks. DoD directive 5205.15E established the DOD Forensic Enterprise charged with maintain a global forensic capability. This capability includes a biometrics database as well as in theater forensic lab capability. These strategic assets along with soldiers equipped with biometric collection devices, and forensics data such as finger prints and DNA collected at blast sites, allow for individual targets are identified (Eisler, 2012). These are examples of just a few of the many efforts that JIEDDO is pursing in the AtN domain.

AtN is an important, if not the most important LOO with respect to defeating the insurgencies weapon of choice on the strategic level (Eisler, 2012). AtN has double the funding of TtF however, is considerably less than DtD (JIEDDO, 2008, 2009, 2011). Denying the resourcing, manufacture, employment of IEDs degrades the insurgent's capability to gain strategic success. The lack successful attacks aids coalition forces greatly in gaining the confidence of the local population perception of protection. Perception of protection is important. A population that feels protected and has more confidence in his or her host nation police and military, thus the populous is more likely to aid the coalition forces. A populous that does not have such confidence is less likely to aid the coalition (Garaux, 2009). Attack the network is an important piece of building populous confidence in host nation and coalition forces by identifying and defeating IED networks, it adds stability and reduces fear among the local populous by reducing both attack frequency and real danger within a local area.

Defeat the Device

DtD is the line of operation providing equipment to successfully detect and neutralize IEDs before they detonate or mitigate the effects of the detonation at the point of attack to ensure freedom of movement and safer operations (JIEDDO, 2012). These activities are enabled by rapid identification, development, acquisition, and delivery of capabilities for route clearing, device and explosive detection, improved EOD robots, and better vehicle and personnel protections. Clearly, this pillar definition describes technology as the means to defeat the IED. Note that most of the language in the description is defensive in nature.

DtD accounts for the majority of JIEDDO's efforts in terms of monetary outputs (JIEDDO, 2008, 2009, 2011). The DtD focus is based in technological solutions. Many of the initiatives within this domain focus on detection and neutralization at a safe standoff distance (Vane & Quantock, 2011). Defeat the device initiatives range from directed energy weapons to blast resistant underwear. DtD highlights for 2008 included the Ahura hand held homemade explosives detector, lapeer and terrapin culvert denial systems, Husky mounted detection system (armored mine detector), interrogation arms for MRAPs, updated jammers, combat tracker dogs and the Marcbot/Xbot robots for convoys and patrols (Benson, 2012).

Despite the billions of dollars spent in the defeat the device domain, many of the devices fielded have yet to increase the detection rate of IEDs. The average detection rate hovers around 50 percent even with the U.S. best technological efforts (Benson, 2012). Many of the technologies fielded such as the Self Contained Reconnaissance Vehicle (RECCE I) attempt to integrate self-contained optical and robotic deployment systems to allow all of the occupants to stay in the vehicle remotely investigating suspected trouble areas (JIEDDO, 2008). By deploying technologies like this however, removes one of the best detection systems off the battlefield, the soldier.

Train the Force

TtF aims to mitigate the effects of enemy IED employment through the comprehensive training of US forces deploying to threat areas. Training should ensure that deployed troops are aware of the IED threat in their operational area and have an understanding of their missions, functions, and responsibilities, as well as the capabilities of their equipment to mitigate the effects of an IED attack (JIEDDO, 2012) .

The Joint Center of Excellence (JCOE) is the lead organization within JIEDDO supporting TtF. JCOE is responsible for developing training efforts to enable units deploying to theaters of operation the skills necessary to operate CIED technologies in addition to the pre-deployment training on IED technical capabilities and enemy techniques, tactics, and procedures. Training development is another focus, in an effort to ensure soldiers properly employ their CIED equipment and understand its capabilities against the IED (JIEDDO, 2009). Examples of some of the various training initiatives conducted by JIEDDO are the Tactical Site Exploitation (TSE); Home Station Training Lanes (HSTLs) JIEDDO funded the creation of CIED training lanes on 57 different installations, and the Mobile CIED Interactive Trainer (MCIT), which provides self-paced, adaptable, interactive CIED training for a unit’s expected area of operation.

MCITs focus is awareness about IED components, employment strategies, and the function and organization of the IED network (JIEDDO, 2009)

Soldier Detection Based Research

Detection is key in defeating the device. Even with sophisticated sensors and detection devices, mounted patrols have a 41% chance of discovering the IED, while a dismounted patrol has nearly double that at 79% chance (Vanden Brook, 2011). The dismounted success may not be a mystery, doctrine from WWII, Vietnam, and current publications all point to carful, trained observation, as a premier method of detection (*FM 5-31 Boobytraps*, 1965; Jones, 2004). Despite the phenomenal detection capability of the human eye, very few of the 1800+ initiatives overseen by JIEDDO focus or allocate resources to support solider based detection efforts. Those research efforts based on soldier detection however have yet to measure the effectiveness of doctrine.

ROC - IED

The Recognition of Combatants: Counter Improvised Explosive Device (ROC-IED) is one effort that focuses on soldier identification. This program spawned out of the successful computer training program Recognition of Combatants: Vehicles (ROC-V) which aided soldiers in learning the thermal and optical signatures of vehicles, highlighting the unique signatures and patterns when viewing through a forward looking inferred (FLIR) and day optics (Pettitt, Redden, Turner, & Carstens, 2009). Based on the success of ROC-V, JIEDDO contracted Communications Electronics Research, Development and Engineering Center’s (CERDEC)

Night Vision and Electronic Sensors Directorate (NVESD) to develop a training program with a similar approach to the IED threat (Pettitt et al., 2009).

The curriculum for this digital training tool is reflective of a Counter Explosives Hazards Course taught at Ft. Lenordwood, Missouri. JIEDDO contracted the Army Research Institute (ARI) to evaluate the effectiveness of the ROC-IED as digital learning tool. The tool based on the recognition of combatants teaches course material related to CIED procedures and activities. ARI measured the use of the tool as a standalone training aid for subject matter experts (SME) trained in the Counter Explosives Hazards Course, as well as a supplementary tool. 81 soldiers were divided into three groups one which received training only using the ROC-IED program, one group received instructor led training, and the third group received a combination of the two.

The objective of the study compared the effectiveness of the ROC-IED as a standalone and supplementary training aid. To test the effectiveness of the training ARI conducted three tests with the participants of the study. The first two tests consisted of a mounted and dismounted patrol lanes with simulated IEDs along their route and designed to assess the soldiers' ability to recognize IED indicators and to recognize and detect IEDs (Pettitt et al., 2009). The third test was written, designed to test knowledge on IED components, emplacement techniques, and IED principals (Pettitt et al., 2009).

The dismounted lane was a 400-meter lane divided into four 100-meter sections; each participant had four minutes to identify IEDs and IED hazards while moving around the dismounted lane. A horn started each subsection of the dismounted lane. The mounted lane consisted of three participants in three Humvees with an observer controller in the passenger seat and the Student in the turret cupola. As hazards were identified by the student the OC would be notified and not the identification. Of note, the vehicular speed for the test was 15 MPH, which is much slower than typical mounted patrols and convoys. For both the mounted and dismounted lanes, six actors dressed appropriately for the operational environment at the time of the test. These actors represented civilians on the battlefield (COB) and were geographically spread out along both lanes. Some actors were possible indicators while others performed everyday mundane tasks.

ARI's study while important in gathering information about knowledge retention and and measuring the effectiveness of different instruction methods in CIED training, it did not measure nor test doctrine or measure the effectiveness of CIED procedures. Soldiers walked one at a time down the dismounted lane and driven around the mounted lane with the task of identifying IEDs and IED hazards; however they did not complete these tasks as collective entities, which they would do in a combat scenario. Doctrinal approaches, such as those executed at the squad and platoon levels are absent in this study, as detection and knowledge retention focused on the individual moving linearly not accounting for clearing procedures or proper maneuver as applied to a danger area.

Combat Hunter

The Marine Corps Combat Hunter is a program that focuses on perceptual skills of individuals. The program centers on increasing the soldiers ability to perceive and interpret a wide range of stimuli (Schatz, 2011). Examples of perceptual training that occur in a normal training regimen are marksmanship, IED detection training, and of course the Combat Hunter course (Schatz, 2011). The Combat Hunter course does not specifically focus on IED detection but builds on developing higher order cognitive skills that are applicable throughout the battlespace. By improving these skills, one gains efficiency in cognitive tasks such as IED detection. Specifically, Combat Hunter trains techniques for improvement in situational awareness, sense making, mental simulation and dynamic decision making (Schatz, 2011). While this program does not address CIED doctrine or efforts, it does offer individuals the potential to improve one's detection capability.

Gap in Research

JIEDDO has come under criticism for mismanagement of billions of dollars in funding and its insatiable pursuit of technology and a lack of overall strategy in the CIED fight (Sadowski, 2008; Solis, 2009). The overall pursuit of technology has made its way into doctrine. Training and Doctrine Commands efforts in aiding in the CIED fight, created FM 3-34.114 "IED Defeat" which like many other efforts, shifted noticeably from a soldier-centric main effort, toward the techno-centric, in hopes of quickly defeating the threat (Adamson, 2007). The shift in doctrinal approaches has consequences, as pre-deployment training focuses on CIED equipment operation and reactionary tasks (See Annex A), a belief that technological means and vehicle armor is the best protection to soldiers has developed. The belief in equipment superiority has led to the erosion of sound doctrinal procedures. The focus on technological solution and protective mechanisms has likely decreased both tactical ability and creativity. This focus has led to a an un-intended consequence in which the force contradicts current counter insurgency guidance and doctrine simply by utilizing the most current protective equipment (Good, 2010).

Another glaring issue with the efforts in the CIED fight are the lack of metrics to measure the effectiveness of CIED initiatives (Government, 2009). The lack of baseline metrics to compare the various efforts effectiveness, make the techno-centric strategy difficult to evaluate. Many have asked the question “is technology this the right course” while there is without a doubt that some of the efforts have saved lives, without a strategic vision and methods measure success, efforts will continue to fall short of “defeating” the IED (Ellis et al., 2007).

Some suggested alternative solutions to the IED threat are reengaging training efforts while focusing on basic maneuver techniques, tactics, and procedures with less focus on technological devices (Benson, 2012, p. 19; Good, 2010). Lt. General Michael Otes a former director of JIEDDO has said “the best bomb detectors are still working dogs and handlers, local informants, and the trained soldiers eye”, despite this revelation, testing of soldier-centric doctrine, such as that found in FM 3-21.8 is almost nonexistent (Cary & Youssef, 2011 updated 2014). Research in CIED has focused on technological innovations such as sensors, neutralization capabilities, and sophisticated software that can conduct pattern analysis. While research exists such as ROC-IED, Combat Hunter, and Mobile Counter IED Trainer (MCIT) is receiving significant funding aimed with the hope of improving individual detection ability, lacking is a link between this enhanced ability and maneuver doctrine.

Apparent Romanian success by using the “stop and search” procedure like that of doctrine such as that found in FM 3-21.8 suggest that an investigation into the effectiveness of older “soldier centric” doctrine and procedures is warranted. Romanian forces’ casualty rates are extremely low, while utilizing the very equipment that U.S. forces deemed unfit for force protection. Romanian successes rely upon the soldier’s ability to detect, not the ability of their equipment to absorb and deflect a blast. Studying the effectiveness of basic CIED procedures and visual clearance techniques additionally provides a base metric in which to compare the effectiveness of the many technological innovations fielded.

CHAPTER THREE: METHODOLOGY

Purpose of Research

Despite being the most technologically sophisticated and equipped force on the planet, U.S. Forces within Zabul province suffered more casualties due to IED's than their less technologically equipped Romanian ally during 2010 (iCasualties.org, 2015). The question as to why this occurred remains unanswered. The purpose of this research is to develop and implement a methodology to assess competing CIED procedures as a possible explanation to the observed outcomes. As a thesis, the scope of the research is limited to a simulation investigation of two different mounted platoon and squad-level CIED procedures. The research will not address other means to counter IED's such as different equipment, training, or higher-level doctrine. Further, the scope of the simulation of platoon and squad operations will be severely limited. Assumption and scope limitations are discussed in detail below but include the following: day operations, fixed weather conditions, default IED models, and default sensors. Hence, the primary outcome of the research will be methodology to investigate the two research questions posed below. Additional outcomes include possible magnitude of contributing factors to CIED success, improved understanding of some of the potential shortcomings in current CIED efforts and practices, and emergent potential solutions or paths of research that lead to CIED further improvements.

The United States has often relied on technology to establish dominance on the battlefield. The M1A1 tank of Desert Storm fame is but one example. Nevertheless, technological solutions do not always appear to deliver the dominance sought. From a technology perspective, the perceived failure of the HMMWV to adequately protect troops from IED’s spurred a frantic search for technological solutions. United States spent nearly 75 billion dollars on CIED efforts since 2006. Despite this gargantuan expenditure, mounted patrols have maintained roughly a 50 percent strike to find ratio, even with the latest technology available being rapidly fielded (Benson, 2012; Zoroya, 2013). Failures of devices such as the Joint IED Neutralizer (JIN) which was fielded to Afghanistan but never worked and the lack of overall program tracking have led to inquiries into the management of such large scale financially large projects. Cases such as the JIN illustrate the constant focus for finding the next technological silver bullet to defeat the IED (Atkinson, 2007). The pursuit of technological solutions to counter the IED threat has produced the MRAP a successful vehicle possessing increased protections available to the soldier as compared to un-armored and flat-bottomed vehicles, however these protections came at the cost of canalization and being road bound, ultimately providing predictability for the enemy. Choosing a random path, quite literally, the road not traveled is in many instances simply not feasible due to the gargantuan size, center of gravity, and weight of the MRAP blast resistant family of vehicles. The Army’s own Programmatic Environmental Assessment (PEA), which studies the suitability of the vehicle in training environments, as well as assess it overall environmental impact, states:

> “Because of its weight and reduced off road mobility the majority of MRAP vehicles missions will be conducted on roads (approximately 75-85%). The remaining 15-25% of off road travel will be where most of the impact occurs”

While this assessment refers to the environmental impact for U.S. Training areas, the acknowledgement of constrained mobility is directly relatable with the vehicle in combat operations. Especially for operations in countries such as Afghanistan in which mobility for even the HMMWV is severely constrained due to terrain. This self-imposed canalization of operations to roadways, due to equipment limitation, likely exposes soldiers to a higher probability of strike due to route predictability. This effectively allows the enemy to be more efficient in terms of effective weapons placement especially with victim-operated devices such as pressure plates.

The DoD and Army have pledged to continue development of blast resistant vehicles. The Joint Light Tactical Vehicles (JLTV) production is underway with a contract awarded to Oshkosh Truck to build 17,000 at $6.7 billion dollars with an option to build 55,000 amounting to $30 billion dollars. These vehicles will eventually replace the entire HMMWV fleet. Using lessons learned from Afghanistan, the JLTV is significantly lighter and more capable off road than the previous MRAP family of vehicles (Vanden Brook, 2015). Despite being lighter than the previous generations of MRAPs, the JLTV is nearly three times the curb weight of the HMMWV at 14,000 (Gallagher, 2015).

While the MRAP does and the JLTV will afford higher survivability rates than the HMMWV, even a strike in which no fatalities occur, can be an Information Operation (IO) or propaganda victory.

Anecdotally, it appears as the difference in approaching the IED threat between U.S. Forces and the Romanian Army rests in a difference in mounted, platoon and squad-level CIED procedure. Despite having the mission of keeping the only paved road in Afghanistan trafficable through Zabul Province, the Romanian Army was effective in mitigating the IED threat. Contrasting with the U.S. forces, the Romanian forces in particular employed procedures that stopped and cleared a danger area using individual soldiers as visual sensors.

This research focuses on the mounted, platoon and squad-level CIED procedures as based on observations of both the Romanian and U.S. mounted, platoon and squad-level CIED procedures. Given the unique difference between the two procedures, the research focuses on comparing and contrasting the visual detection capabilities of the two different methodologies. Within the research questions, platoon and squad-level CIED procedures conducted by the Romanian Army are referred to as “stop and search” procedure. The platoon and squad-level CIED doctrine observed being used by U.S. Forces in Afghanistan is referred to as “drive through” procedure. The difference between the two procedures rests on vehicle speed, and sensor field. The “stop and search” procedure has a deeper sensor field than “drive through” procedure. The “stop and search” enables dismounted squad members time to visually detect a possible IED. The “drive through” procedure for mounted, platoon and squad-level operations focused on maintaining higher speeds. This meant moving at high rates of speed, which obviously degraded the ability of vehicle crews to detect possible IED’s. The implicit assumption of speed was that the inherent level of protection of the vehicle to withstand an IED detonation would save vehicle lives while the potential loss of one vehicle would not damage overall operations. While obviously increasing the probability of a successful IED strike on a lead vehicle, the “drive through” procedure enabled the patrol to maintain vehicle speed and maneuver capability. .

To clarify the Romanian use of the “stop and search procedure” highlighted within this research are commensurate with U.S. written doctrine as found in FM 3-21.8. The “drive through” procedure employed by observed U.S. Forces is also found within FM 3-21.8 however assumes a less cautious posture. While the majority of the observed U.S. patrols chose a less cautious posture found within doctrine, ultimately the suggested posture to approach a danger area found within the FM is but a guideline and use of specific techniques, tactics, and procedures are at the discretion of the executing on-ground commander unless specified at a higher echelon.

While a separate hypothesis not investigated by this thesis, the reason for the inconsistency between observed procedure choice and written doctrine may be the result of confusion of platoon and squad tactics developed to deal primarily with IEDs and complex ambushes within urban terrain in Iraq. Use of IEDs within urban terrain are characterized by enemy tactics that include various command IED detonation methods often followed by complex ambushes. Complex ambushes are intended to destroy forces such as an entire squad, platoon, or convoy that are larger in size than a single vehicle. Complex ambushes involve not only IED detonation but also direct fire and other anti-personnel weapons directed at an entire convoy, patrol, or defending force rather than simply a lead vehicle. In complex ambushes, an IED detonation may initiate the ambush to stop the lead vehicle and thereby stop a convoy making the entire convoy a target. Defense against a complex ambush may be best accomplished through maneuver and the firepower of those maneuvering elements. Hence, the emphasis on vehicle speeds and maneuvers. Some of the success in countering complex ambushes and other successful CIED techniques in Iraq, an area with concentrated urban sprawl, may have led to the decreasing use in Afghanistan of the “stop and search” procedure. This research does not address the above hypothesis about the reasons for the differences in the CIED procedure choice, but rather the consequences of the two procedures.

Research Questions

Research Question: Is the “stop and search” procedure more effective in IED detection and casualty prevention than the “drive through” procedure?

Hypothesis: 1

H0: “Stop and Search” CIED procedure is equally as effective as the “drive through” CIED procedure at detecting the IED threat.

Ha: “Stop and Search” CIED procedure is more effective in detecting the IED threat to that of the “drive through” CIED procedure.

Hypothesis 2

H0: “Stop and Search” CIED procedure is equally as effective as the “drive through” CIED procedure preventing casualties.

Ha: “Stop and Search” CIED procedure is more effective at preventing casualties to that of the “drive through” CIED procedure.

Assumptions

MAK VR Forces provides a high fidelity environment to accomplish threat detection as modeled according to the fundamental doctrine found with in FM 3-21.8 and that of the observed field based doctrine. 1600 runs of both models provide a significant base for statistical analysis; enabling a comparison between models and identifying visual detection efficiencies with respect to fundamental doctrine and observed field doctrine. The sensors provided with VR Forces are of adequate fidelity and resolution to make recommendations for further research. The Navy, Army, and Air force currently use MAK VR Forces in several different simulation platforms. JIEDDO also has collaborated and used MAKs software for research and development (MAK, 2015a). VR Forces coupled with MAK Logger is a suitable experimentation platform to perform visual detection analysis.

Scope and Limitations

The experiment will be limited to the default sensors and models that are available within VR Forces. The approach section of this chapter notes the few modifications to the default models and sensors. As a commercial off the shelf solution VR Forces features a wide variety of simulation capability. Some of these capabilities will be purposely limited to reduce the number of variables affecting the outcome of visual detection. One such variable, artificially fixed for the experiment, is weather. VR Forces has the capability to seed random weather patterns for scenarios, for this experiment the same weather profile, as well as the same time of day is standard for all simulation runs. This ensures the luminescence profiles and atmospheric conditions are not a variable factor between runs. Since luminescence profile and atmospheric conditions along with sensors influences probability of detection, the choice to limit the profile and conditions limits the extensibility of conclusions from the Mak portion of the research to those selected luminescence profiles and atmospheric conditions.

The scenario is limited in the number of participants and to activities of those participants shortly before encountering a danger area or IED, and does not attempt to replicate a full tactical response. For instance, if the IED detonates the model does not follow through with a cordon of the area, furthermore if a detection occurs the vehicle or soldier that detected the object stops and signals to the other entities to stop ending the scenario. EOD and Sapper actions are absent from the models, after an entity detects a threat such as the IED, for the purposes of this experiment the threat is considered neutralized. The intent of the models is not to replicate a full-fledged tactical scenario, but rather to capture outcomes from the two doctrines of clearing danger areas and comparing the effectiveness of the doctrines.

This experiment is a simulation in its entirety. This in itself is somewhat of a limitation. Past experiments modeling combat operations have shown that modeling can provide generally accurate models for combat; however, some tasks when compared to live testing do not fully correlate (Proctor & Paulo, 1996). Fully simulated experiments are a useful tool in reducing risk associated and predicting potential outcomes with live and virtual trials. Funding, participant pool, and time have necessitated a fully simulated experiment; however, the .goal of this experiment is not to provide a definitive solution to the IED problem. A goal of the experiment is identify a potential solution by providing evidence prompting further research and study. The models created while in a full constructive environment will facilitate this goal.

Visual scanning is currently not available within MAK VR Forces by default though the visual sensors are configurable to constrain the visual field to a frustum of less than the default 360 degrees. By implementing a frustum each visual field has 120 degrees of horizontal view, with vertical restrictions, all of which are in line with MIL STD 1472G. Limitations include the primary fovea, peripheral fields are not discriminated, and the inability to scan with an optimal field of view limits realism of the result.

Variability in size, shape, and placement of an IED can influence probability of detection. The IED model default to MAK VR Forces is one representing a modified 155 mm artillery round. Having a consistent object model is useful as a control for analysis of the two models but again limits extensibility of results. This 155 mm is the only IED included within the VR Forces 4.2.2 package. In reality, IEDs range from ones in a soda can, to cars chalked with explosives.

Vehicle damage is not a variable for this experiment. MRAPs provide superior blast resistance on the battlefield, thus damage taken by vehicles is not the focus of this experiment. The focus is on the techniques used to identify IEDs before a strike. To eliminate sensor position as a variable, both models will feature the same vehicular test platform. Both damage and destruction tally the same; both instances count as a strike or in essence a failure to detect prior to initiation. One vehicular model represents vehicles on both doctrine models to eliminate sensor position as a variable.

Approach

A comparison of the two doctrines is possible by modeling the two approaches within MAK VR Forces 4.2. The models created are identical with respect to IED placement and route. In many respects this experiment is similar in design to the IED lane noted within the ROC CIED study conducted by the Army Research Institute (Pettitt et al., 2009). While the ROC lane was a live simulation and had multiple threats, the models constructed for this experiment resemble a segment of that lane in its entirety.

Each lead vehicle modeled in VR Forces for this experiment contains three human visual sensors per vehicle to detect threats. The sensors represent the diver, passenger, and gunner positions. Should one of the sensors detect an IED, the vehicles in the patrol will stop assuming IED neutralization and ending the scenario. Should the IED not be detected or detected too late, the IED potentially can destroy the vehicle, miss or damage the vehicle, or not be triggered. To model the “stop and search” procedure in VR Forces, a box is used to indicate a “danger area” this trigger initiates a script to dismount troops to conduct a visual search to clear the danger area containing the IED. The box trigger represents a perceived danger area, it is necessary as the visual sensors only detect objects within the database. The box is a realistic choice as trash and debris can be indicators of a danger area. Any specified entity within the database is capable of fulfilling the same role as the box. The “drive through” procedure model does not react to the box as trigger to dismount troops. The box is present though it is not required for the “drive through” procedure, as dismounted visual clearance is not part of this model. The lack of reaction to the box does not increase or decrease the probability of success or failure of the outcome it. Likewise, “stop and search” procedure model, if the troops do not detect the IED or detect it too late, they are killable, or if the vehicles do not detect the box representing the danger area, they will continue on the route exposing the mounted patrol to the IED threat much like the drive through model. Figure 3 is a visual representation of the route.

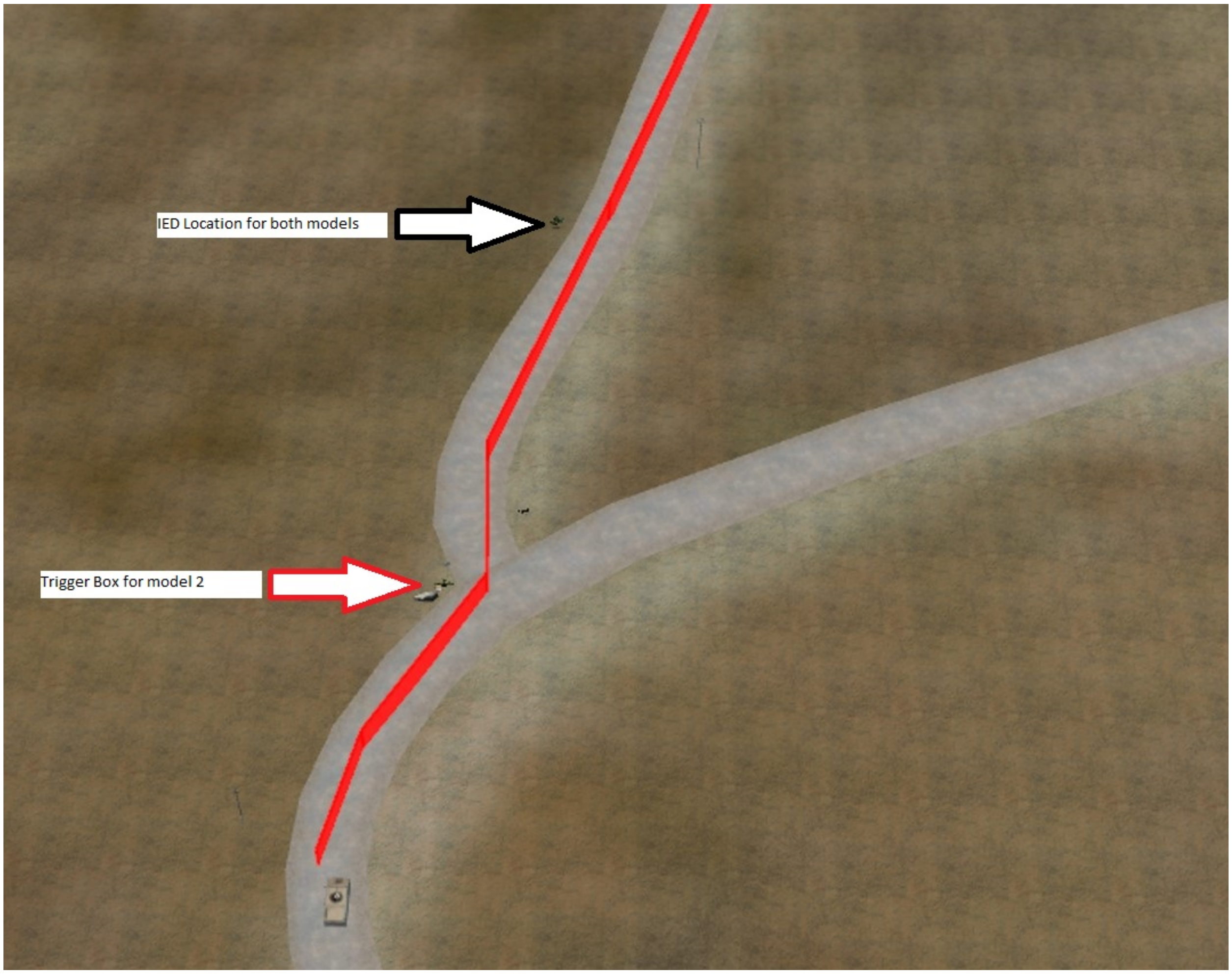

Figure 3: Route for procedure models

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HMMWV with M2 is the model used to represent vehicles within the experiment. This model is a default model within VR Forces. By utilizing the same vehicular model in both doctrinal approaches, sensor locations are the same, eliminating sensor location as a variable. The MRAP model within VR Forces is not a 3D model and is generic vehicle shape with a heavy armor destruction profile. This heavy armor profile is available to the HMMWV with M2 model enabling the same protection level for the model.

The default visual sensor within VR Forces has a 360 field of view. Additionally by default, the visual sensor locations on the models are located exactly in the center of the models. The “Human Visual Sensor” a modification to the default visual sensor applies a more accurate visual sensing capability through the use of a frustum limiting the field of view to specifications denoted in MIL STD 1472G (D. o. Defense, 2012, p. 89). In addition, each vehicle contains three human sensors denoted by the top three green dots, representing the driver, passenger, and gunner (FIGURE 7). These three sensors were purposely located at the illustrated marks and represent accurate sensor location. The complete default sensor file and the “human sensor file are located in APPENDIX B.

The visual sensor determines that the level of information that is available about sensed objects by calculating Line of Sight (LOS), detected or detectable object signature, and atmospheric effects on detection. Detection occurs in four stages: detection, classification, identification, and full knowledge. Movement speed also plays a factor in detection, as target exposure time to the sensor is a factor in determining the target objects level of detection (MAK, 2015b).

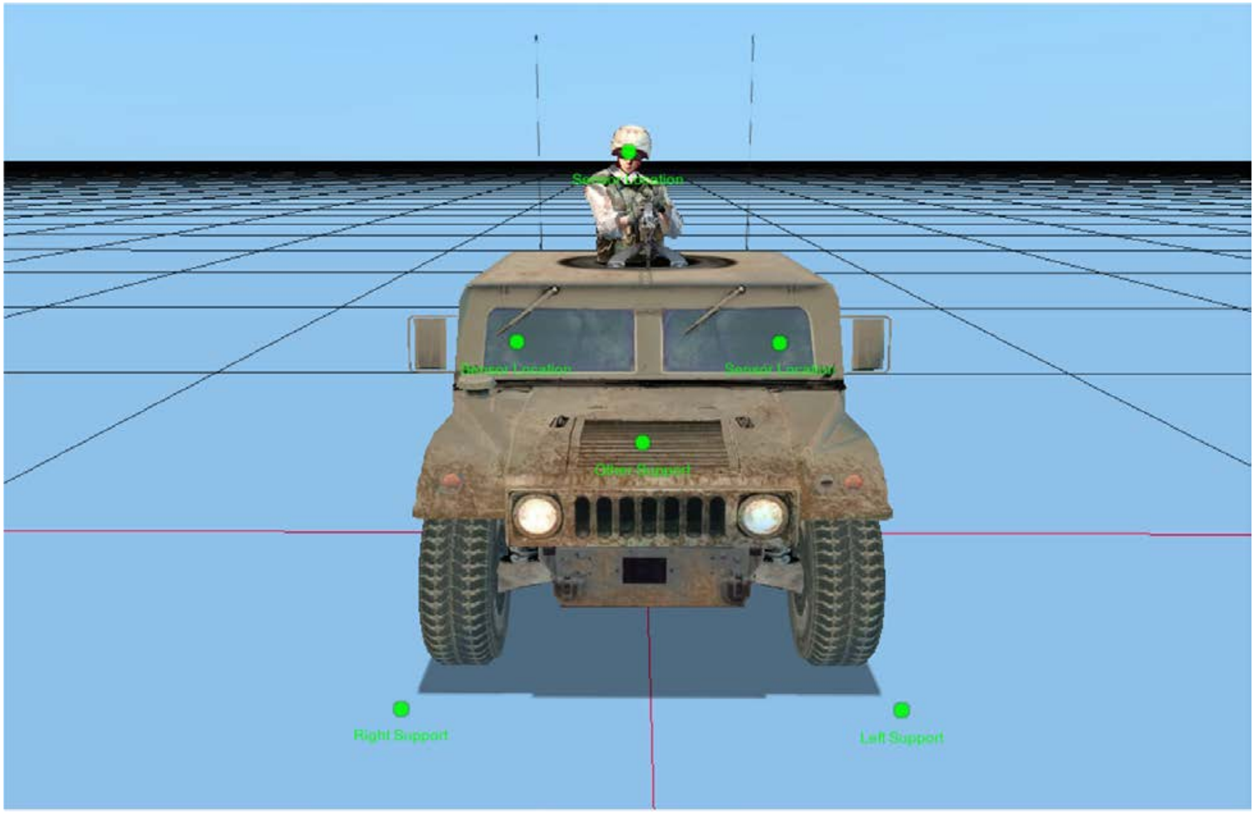


Figure 4: Mounted "Human" Sensor Locations

The IED in default configuration is a rendering of a 155mm howitzer shell. While not an ideal representation for all IEDs it is a common munition used in such devices, the small visual signature of the IED is adequate to measure visual detection between the two methods. The default IED model found within VR Forces is 1.6 meters long by 1 meter wide, by 1 meter high. This size is nearly double the actual size of a 155mm artillery projectile. The model size was reduced to reflect the real world size of the IED with the dimensions of .684022 long by .15798 meters high x .15798 meters wide (*Army Ammunition Data Sheets: Artillery Ammunition Guns, Howitzers, Mortars, Recoilless Rifles, Grenatde Launchers, and Artillery Fuzes (FSC 1310, 1315, 1320, 1390)*, 1994). Activation of the IED occurs by specifying one of three modes: proximity, time, and immediate. For proximity mode, a radius in meters is required when arming the device. If any entity moves within the specified field than the device will detonate. In terms of the simulation, the proximity sensor is a collision box. Time mode: requires the operator to enter a time based on the elapsed simulation time, at the specified time the IED will detonate. Immediate mode, allows the operator or controller to detonate the IED at any time by selecting the mode. This is most useful in virtual experimentation, in which human subjects are representing avatars within the simulation. For the purposes of this experiment, to represent the most common type of IED or the victim operated IED, the proximity sensor is best suited for this experiment and is the preferred method of employment.

Target Audience

Target audience for this research is for the smallest maneuver unit to a logistical convoy. Any element that maneuvers within battle space during a conflict will potentially benefit from this and future research in this area. Maneuver elements endure most of the IED threat, as such modeling and researching promising techniques and procedures that increase detection efficiencies potentially leads to casualty reductions.

Experimental Design and Data Collection Methods

MAK Logger is a program designed to capture both simulation data and playback simulations. When configured, it outputs log files in text, excel, SQL, and a proprietary logger format. Logger 5.3.1 is the primary tool in gathering data from the simulations. Logger captures entity ID, entity type, force ID, location, velocity, acceleration, orientation, angular velocity, damage state, detonation state (IED only), kill state, immobilization state, any concealment, and enabled capabilities. Logger also captures system messages such as detection and detection levels. By running both the “stop and search” procedure and “drive through” procedure 1600 times, with the data exported into a SQL database from MAK Logger, analysis is possible with respect to the detection capabilities of the two procedures. A sample plain text logger output file is in Appendix D. This file highlights the available data for comparison within the SQL database.

Once the data for the two procedures is in the SQL database, an import to SPSS, a statistical analysis program is possible. SPSS v23 processes and handles all analysis. SPSS is capable variety of statistical tests for analysis. To answer the question 1, a Mann Whitney U test concerning the detection variable from both procedures is necessary for comparison. An A priori test as well as a post hoc power test using G power provides power analysis that will support either the rejection or acceptance of the null hypothesis during analysis.

CHAPTER FOUR: DATA COLLECTION AND ANALYSIS

Introduction

This chapter presents the data collected and utilized for analysis for a cumulative of 67,200 runs of the "stop and search" and "drive through" CIED procedure models. The primary focus of this thesis is to determine what if any impact the use of two different CIED procedures has on the ability to detect IEDs, avoid strikes or prevent casualties. Comparing the two procedures - "drive through" and "stop and search" - for strikes and casualties is possible by analyzing data gained from the simulations. Strikes as well as vehicles destroyed/casualties are the metrics used for the basis of comparison.

The MAK Logger 5.3.1 recorded simulation run data. From the logger, the data export feature transferred the data into a SQL database. Data queries from excel into the SQL database pulled and filtered the data and array the data for analysis by SPSS. SPSS v23.0 GradPack and G*Power 3.1.9.2 performed all inferential and descriptive statistical analysis.

The principle data extracted for analysis were: (1) detonation PDU (protocol data unit), (2) force identification, and (3) entity state PDU. The simulation only generates a detonation PDU when a detonation occurs, this allows for an accurate accounting of the number of detonations per the number of runs conducted. Likewise, the entity state PDU provided an effective method to filter and identify totally destroyed vehicles or dead soldiers within the stop and search model. The entity state PDU differs depending on the entities state and the final PDU sent within the simulation. The final entity state PDU makes it possible to capture the final state of all entities within the simulation. Using the final PDU appearance codes, enabled filtering of simulation data to reflect the number of totally destroyed vehicles and killed entities within each respective sample. For the totally destroyed vehicle within the simulation all five-occupant entities die resulting in five causalities per vehicle destroyed within the “drive through” model noted in the total potential casualties. In reality, despite total vehicle destruction, the actual casualty count will vary based on a multitude of factors that this model does not account for. Because of this disparity, both the raw vehicular destruction frequency and a corrected “potential casualty count” are reflected in the graphed results (Figure 5).

Statistical Analysis

G*Power 3.1.9.2 enables a priori estimation the initial sample size required for statistical testing given the required power level (1-beta) at a specified significance level (alpha), and desired effect size. Post hoc testing using the collected data determines the actual observed power.

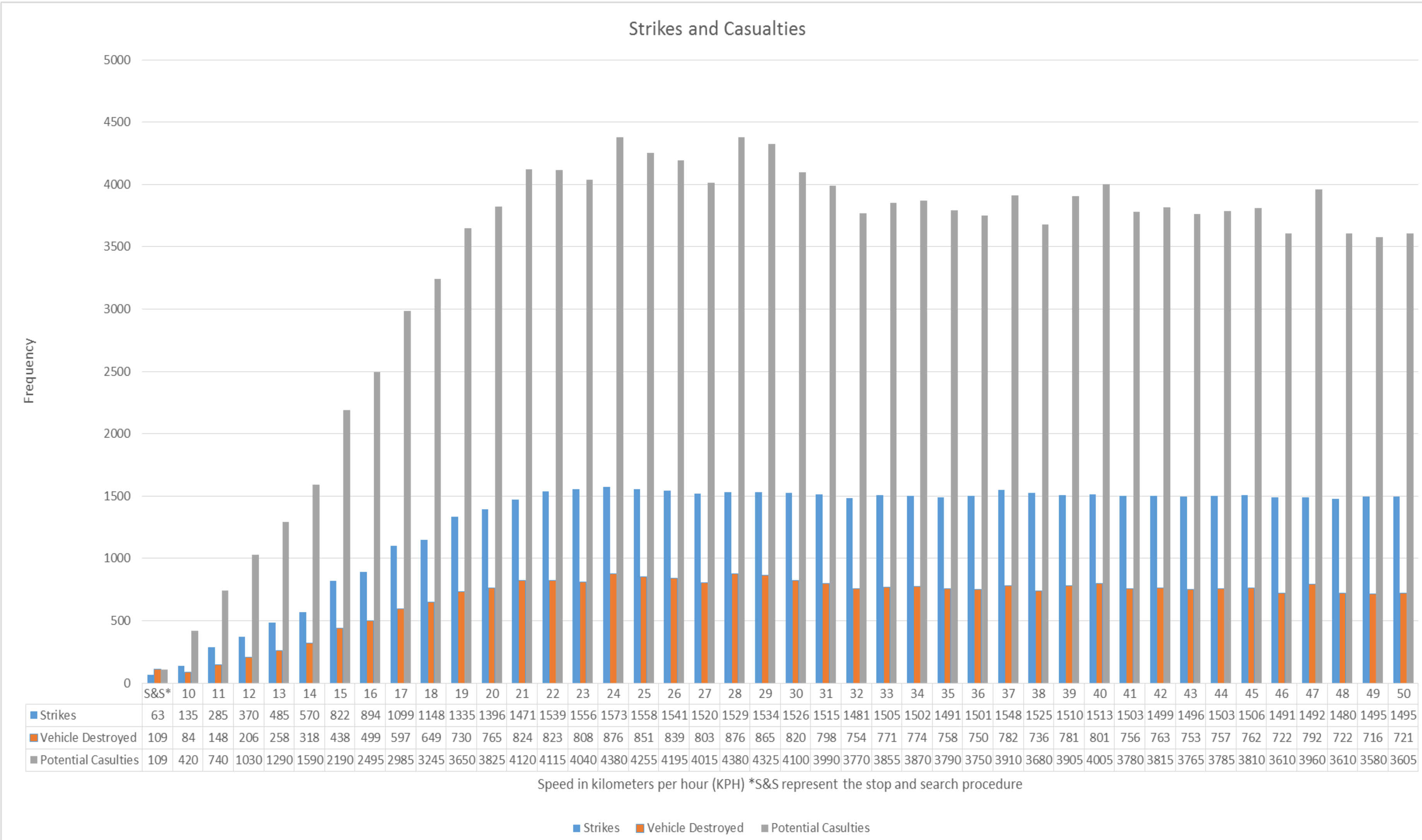
The power estimation and post hoc testing are important in minimizing type 1 and 2 errors. Type 1 error commonly referred to as an alpha error, in which one incorrectly rejects the null hypothesis. A common control to minimize this type of error is to fix the alpha level threshold for rejection of the null hypothesis (Diez, Barr, & Cetinkaya-Rundel, 2015). For instance, the alpha level of this experiment is .05, which gives 95 percent probability that type 1 error did not occur. Type 2 error is known as beta error or the failure to reject an incorrect null hypothesis. Power (1-beta) and beta complement each other by conducting post hoc analysis, one can control for type 2 error. To reject the null hypothesis for the research questions, the p-value should not exceed the alpha threshold of .05 nor should the beta level exceed .20. These thresholds are based on recommendations made in *A Power Primer* (Cohen, 1992).

A priori estimation resulted in a sample size requirement of 134 at an alpha error probability of .05 and a beta level of .80 for each of the Mann-Whitney U tests. Each planned comparison contains 3200 samples, which far exceeds the base line requirement determined a priori.

The experiment contained 67,200 runs composed of 1600 runs of the base case “stop and search” procedure at the default pace of 6 km per hour and 1600 runs of the “drive through” procedure at each one-kilometer increments from 10-50 KPH for a total of 41 comparisons with the base case. Speeds above 50 KPH were not tested. The distance between the curve at the intersection, road material, and the linear distance to the IED prevented vehicular acceleration and speed in excess of 51 KPH on a consistent basis.

Data collected on each run enabled comparison of outcomes associated with each procedure, targeted specifically the number of detonations/strikes, and casualties that occurred. Entity state and detonation state and their respective sub categories allowed access to a combination of appearance codes, force identification, and entity marking sets data that enabled both strike and casualty analysis.

The following paragraphs detail the Mann-Whitney U test statistics and p-values for both strikes and casualties at a given speed for the drive through procedure compared to the stop and search procedure. The “drive through” procedure regardless of speed proved to be significantly different from the “stop and search” procedure. Figure 5 notes the strike and casualty frequencies for each model and speed. Appendix E contains the actual output from SPSS for each of the tests.



	S&S*	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Strikes	63	135	285	370	485	570	822	894	1099	1148	1335	1396	1471	1539	1556	1573	1558	1541	1520	1529
Vehicle Destroyed	109	84	148	206	258	318	438	499	597	649	730	765	824	823	808	876	851	839	803	876
Potential Casulties	109	420	740	1030	1290	1590	2190	2495	2985	3245	3650	3825	4120	4115	4040	4380	4255	4195	4015	4380

	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Strikes	1534	1526	1515	1481	1505	1502	1491	1501	1548	1525	1510	1513	1503	1499	1496	1503	1506	1491	1492	1480	1495	1495
Vehicle Destroyed	865	820	798	754	771	774	758	750	782	736	781	801	756	763	753	757	762	722	792	722	716	721
Potential Casulties	4325	4100	3990	3770	3855	3870	3790	3750	3910	3680	3905	4005	3780	3815	3765	3785	3810	3610	3960	3610	3580	3605

Figure 5: Strike and Casualty Frequency

Inferential Analysis of the Research Questions:

A Mann Whitney U test of the simulated "stop and search" CIED procedure to the "drive through" CIED procedure for both strikes and casualties at each speed from 10 KPH to 50 KPH facilitated the inferential analysis of the research question and hypotheses stated below.

Research Question: Is the "stop and search" procedure more effective in IED detection and casualty prevention than the "drive through" procedure?

Hypothesis:

H0: "Stop and Search" CIED procedure is equally as effective as the "drive through" CIED procedure at detecting the IED threat.

Ha: "Stop and Search" CIED procedure is more effective in detecting the IED threat to that of the "drive through" CIED procedure.

The measure used to evaluate this hypothesis was IED "strikes"

H0: "Stop and Search" CIED procedure is equally as effective as the "drive through" CIED procedure preventing casualties.

Ha: "Stop and Search" CIED procedure is more effective at preventing casualties to that of the "drive through" CIED procedure.

The measures used to evaluate this hypothesis were vehicle destroyed and potential casualties. As vehicle destroyed is correlated with potential casualties, statistical analysis is performed primarily on casualties.

Appendix E contains statistical output for each set of runs. Table 1 summarizes the statistical outcomes for each set of runs. The first column S & S represents the “stop and search” procedure while the second represents the “drive through” procedure at the given speed.

Table 1: Statistical summary of outcomes.

Summarized Statistical Outcomes								
Procedure Comparison			Mann-Whitney U Test Statistic		Significance		Post Hoc	
			Strike	VehDstry	Strike	VehDstry	Power	Beta
S&S	VS	10 kph	1222400.000	1263280.000	0.000000	0.075782	1.00	0
S&S	VS	11 kph	1102400.000	1213360.000	0.000000	0.000000	1.00	0
S&S	VS	12 kph	1034400.000	1168120.000	0.000000	0.000000	1.00	0
S&S	VS	13 kph	942400.000	1127560.000	0.000000	0.000000	1.00	0
S&S	VS	14 kph	874400.000	1080760.000	0.000000	0.000000	1.00	0
S&S	VS	15 kph	672800.000	987160.000	0.000000	0.000000	1.00	0
S&S	VS	16 kph	615200.000	939580.000	0.000000	0.000000	1.00	0
S&S	VS	17 kph	451200.000	863140.000	0.000000	0.000000	1.00	0
S&S	VS	18 kph	412000.000	822580.000	0.000000	0.000000	1.00	0
S&S	VS	19 kph	262400.000	759400.000	0.000000	0.000000	1.00	0
S&S	VS	20 kph	213600.000	732100.000	0.000000	0.000000	1.00	0
S&S	VS	21 kph	153600.000	686080.000	0.000000	0.000000	1.00	0
S&S	VS	22 kph	99200.000	686860.000	0.000000	0.000000	1.00	0
S&S	VS	23 kph	85600.000	698560.000	0.000000	0.000000	1.00	0
S&S	VS	24 kph	72000.000	645520.000	0.000000	0.000000	1.00	0
S&S	VS	25 kph	84000.000	665020.000	0.000000	0.000000	1.00	0
S&S	VS	26 kph	97600.000	674380.000	0.000000	0.000000	1.00	0
S&S	VS	27 kph	114400.000	702460.000	0.000000	0.000000	1.00	0
S&S	VS	28 kph	107200.000	645520.000	0.000000	0.000000	1.00	0
S&S	VS	29 kph	103200.000	654100.000	0.000000	0.000000	1.00	0
S&S	VS	30 kph	109600.000	689200.000	0.000000	0.000000	1.00	0
S&S	VS	31 kph	118400.000	706360.000	0.000000	0.000000	1.00	0
S&S	VS	32 kph	145600.000	740680.000	0.000000	0.000000	1.00	0
S&S	VS	33 kph	126400.000	727420.000	0.000000	0.000000	1.00	0
S&S	VS	34 kph	128800.000	725080.000	0.000000	0.000000	1.00	0
S&S	VS	35 kph	137600.000	737560.000	0.000000	0.000000	1.00	0
S&S	VS	36 kph	129600.000	743800.000	0.000000	0.000000	1.00	0
S&S	VS	37 kph	92000.000	718840.000	0.000000	0.000000	1.00	0
S&S	VS	38 kph	110400.000	754720.000	0.000000	0.000000	1.00	0
S&S	VS	39 kph	122400.000	719620.000	0.000000	0.000000	1.00	0
S&S	VS	40 kph	120000.000	704020.000	0.000000	0.000000	1.00	0
S&S	VS	41 kph	128000.000	739120.000	0.000000	0.000000	1.00	0
S&S	VS	42 kph	131200.000	733660.000	0.000000	0.000000	1.00	0
S&S	VS	43 kph	133600.000	741460.000	0.000000	0.000000	1.00	0
S&S	VS	44 kph	128000.000	738340.000	0.000000	0.000000	1.00	0
S&S	VS	45 kph	125600.000	734440.000	0.000000	0.000000	1.00	0
S&S	VS	46 kph	137600.000	765640.000	0.000000	0.000000	1.00	0
S&S	VS	47 kph	136800.000	711040.000	0.000000	0.000000	1.00	0
S&S	VS	48 kph	146400.000	765640.000	0.000000	0.000000	1.00	0
S&S	VS	49 kph	134400.000	770320.000	0.000000	0.000000	1.00	0
S&S	VS	50 kph	134400.000	766420.000	0.000000	0.000000	1.00	0

While individual statistical run outcomes varied, at the experimental design alpha of .05 and beta of .2 statistical significance levels, both null hypotheses may be rejected as the "stop and search" procedure is statically significantly different and therefore more effective in detection of the IED threat than the "drive through" procedure. The one exception is for casualties at 10 KPH. The significance level only compares vehicles destroyed vs the soldiers killed in the stop and search model, if the assumption that the crew is killed in the drive through model, then the stop and search model remains more efficient.

Possible explanations for this overall outcome include the "stop and search" procedure benefits from one more soldier-based sensor than the "drive through" procedure. This additional sensor potentially increases the probability that detection of the IED will occur in the "stop and search" procedure over the "drive through" procedure prior to a strike. Additionally the dismounted formation of "stop and search" procedure enables a broader search area. This broader search area is due to the physical distance between the four dismounted sensors. The "drive through" procedure has a narrower search field, as all three sensors are in very close proximity being roughly one meter apart one the horizontal axis. The broader search coverage of the "stop and search" model ultimately offers more coverage with a better probability of detecting a hostile threat.

A second factor that may explain the difference in outcome between the two procedures is speed. Both models base detection on the size of the object being sensed (IED), LOS and distance from the object, and object exposure time. With the "stop and search" procedure, exposure time or time to detect an object is greater than that of the "drive through" procedure. As speed increases with the drive through procedure, it potentially decreases the exposure time to the hostile object, ultimately decreasing the probability of detection. Figure 5 illustrates the effect of speed on both strikes and casualties.

Regression Analysis

The question surfaces, what if a vehicle moved at a speed faster than 50 kph? Both strikes and casualties peak at 24 kph and seemed to have an observable negative slope out to 50 KPH. To explore this further, initially a two-sample Kolmogorov-Smirnov test was used to see if 24 KPH and 50 KPH were members of the same distribution. The Kolmogorov-Smirnov test is a non-parametric test that measures the equality of one-dimension probability distributions. The test resulted in a p value of 0.044629 for strikes and 0.000001 for vehicles destroyed/casualties. Since both do not exceed the .05 significance level, we must conclude that 24 KPH and 50 KPH are not members of the same distribution.

Following this test, a linear regression was conducted using data points between 24 KPH to 50 KPH. Linear regression is used to show relationship between the dependent and independent variables. Using known data the linear regression procedure outputs estimated model parameters. These parameters are derived from essentially a best fit line from the given data. These model parameters can then be used for form a regression equation with the ability to predict future outcome with a given independent value. For the purposes of this paper, the given independent value would be speed.

The regression for strikes from 24 KPH to 50 KPH produced a constant of 1587.205 with a slope of -2.034. The model summery yielded an R Square value of .496 indicating that speed accounts for 49.6 percent of the strikes within the regression model. Further, the 95% confidence interval for the slope is between -2.878 and -1.189. Figure 6 details the regression results for strikes.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1587.205	15.509		102.344	.000	1555.265	1619.146
	Speed	-2.034	.410	-.704	-4.958	.000	-2.878	-1.189

a. Dependent Variable: Strikes

Figure 6: Strike linear regression coefficient results for speeds 24 to 50 KPH

From the given parameter data, a regression equation to predict strikes at a given speed is formulated.

Strikes at (Speed) = -2.034 * (Speed)+1587.205

The same process for vehicles destroyed is used. The regression for vehicle destroyed produced a constant of 959.239 and a slope of -4.805. The model summery R square value was .650 indicating that speed accounted for 65% of the vehicles destroyed within the regression model. The 95% confidence interval for slope was wider than that of strikes at -6.258 to -3.353. Figure 7 details the regression results for vehicles destroyed

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	959.239	26.663		35.977	.000	904.326	1014.152
	Speed	-4.805	.705	-.806	-6.814	.000	-6.258	-3.353

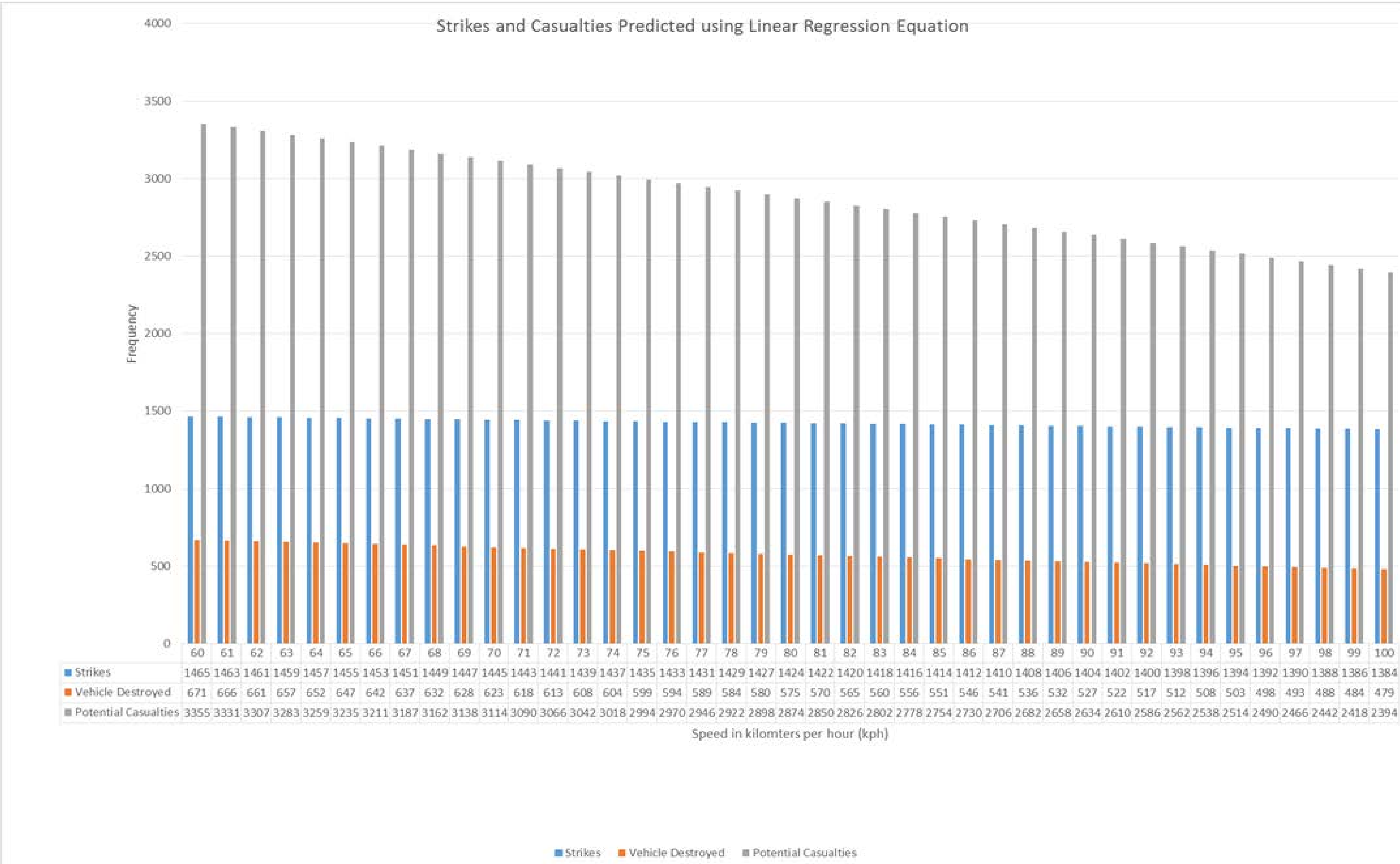
a. Dependent Variable: Casualties

Figure 7: Vehicle destroyed linear regression coefficient results for speeds 24 to 50 KPH

From the given parameter data and assuming linearity, a regression equation to predict vehicles destroyed at a given speed 24 KPH or faster is formulated.

Vehicles Destroyed at (Speed) = -4.805 *(Speed)+959.239

Assuming linearity, the regression equations both strikes and casualties were calculated for speeds from 60 KPH to 100 KPH, which is typically faster than the speed tactical vehicles operate at during military operations in rural Afghanistan. The results of these calculations are noted in figure 8.



	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Strikes	1465	1463	1461	1459	1457	1455	1453	1451	1449	1447	1445	1443	1441	1439	1437	1435	1433	1431	1429	1427	1424
Vehicle Destroyed	671	666	661	657	652	647	642	637	632	628	623	618	613	608	604	599	594	589	584	580	575
Potential Casualties	3355	3331	3307	3283	3259	3235	3211	3187	3162	3138	3114	3090	3066	3042	3018	2994	2970	2946	2922	2898	2874

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Strikes	1422	1420	1418	1416	1414	1412	1410	1408	1406	1404	1402	1400	1398	1396	1394	1392	1390	1388	1386	1384
Vehicle Destroyed	570	565	560	556	551	546	541	536	532	527	522	517	512	508	503	498	493	488	484	479
Potential Casualties	2850	2826	2802	2778	2754	2730	2706	2682	2658	2634	2610	2586	2562	2538	2514	2490	2466	2442	2418	2394

Figure 8: Strikes and Vehicle destroyed/ casualty predictions based on linear regression

The results indicate that both strikes and vehicles destroyed are significantly lower at 100 KPH; however, the “Stop and Search” tactic and the “Drive Through” have the same intercept when the “Drive Through” model reaches an approximate 749 KPH. Vehicles destroyed/casualties are not as extreme with the intercept occurring at the approximate speed of 196 KPH. These results indicate that speed does not necessarily equate to security with respect to the IED.

Detailed comparison of each speed is in the following paragraphs below. Each comparison has two paragraphs describing results one for strikes and one for casualties. Each series of tests seeks to answer the research question consisting of the same hypotheses. Each test seeks to answer the same set of hypothesis therefore; they are not repeated within the body of results for each test.

Stop and Search vs Drive Through: 10 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 10 KPH, U = 1222400.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search model is more effective in detecting the IED threat than the drive through model at 10 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 10 KPH U = 1263280.000, p = .076 the p-value is greater than the .05 threshold therefore we must accept the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceeded thus the acceptance of the null hypotheses is supported. The acceptance of the null hypothesis indicates that the "stop and search" procedure is not more effective at preventing casualties than the "drive through" procedure at 10 KPH based on the corrected potential casualties.

Stop and Search vs Drive Through: 11 KPH

A Mann-Whitney U test indicated that strikes were less for "stop and Search" procedure than the "drive through" procedure at 11 KPH yielding the following: U = 1102400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective in detecting the IED threat than the drive through model at 11 KPH.

A Mann-Whitney U test indicated that casualties were less for "stop and Search" procedure than the "drive through" procedure at 10 KPH yielding the following: U = 1213360.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective at preventing casualties than the "drive through" procedure at 11 KPH.

Stop and Search vs Drive Through: 12 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 12 KPH yielding the following: U = 1034400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 12 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 12 KPH yielding the following: U = 11168120.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 12 KPH.

Stop and Search vs Drive Through: 13 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 13 KPH yielding the following: U = 942400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop

and search" procedure is more effective in detecting the IED threat than the drive through model at 13 KPH.

A Mann-Whitney U test indicated that casualties were less for "stop and Search" procedure than the "drive through" procedure at 13 KPH yielding the following: U = 1127560.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective at preventing casualties than the "drive through" procedure at 13 KPH.

Stop and Search vs Drive Through: 14 KPH

A Mann-Whitney U test indicated that strikes were less for "stop and Search" procedure than the "drive through" procedure at 14 KPH yielding the following: U = 874400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective in detecting the IED threat than the drive through model at 14 KPH.

A Mann-Whitney U test indicated that casualties were less for "stop and Search" procedure than the "drive through" procedure at 14 KPH yielding the following: U = 1080760.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not

exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 14 KPH.

Stop and Search vs Drive Through: 15 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 15 KPH yielding the following: U = 672800.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 15 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 15 KPH yielding the following: U = 1987160.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 15 KPH.

Stop and Search vs Drive Through: 16 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 16 KPH yielding the following: U = 615200.000, p = .000

the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 16 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 16 KPH yielding the following: U = 939580.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 16 KPH.

Stop and Search vs Drive Through: 17 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 17 KPH yielding the following: U = 451200.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 17 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 17 KPH yielding the following: U = 863140.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 17 KPH.

Stop and Search vs Drive Through: 18 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 18 KPH yielding the following: U = 412000.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 18 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 18 KPH yielding the following: U = 822580.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis

indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 18 KPH.

Stop and Search vs Drive Through: 19 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 19 KPH yielding the following: U = 262400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 19 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 19 KPH yielding the following: U = 759400.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 19 KPH.

Stop and Search vs Drive Through: 20 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 20 KPH yielding the following: U = 213600.000, p = .000

the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 20 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 20 KPH yielding the following: U = 732100.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 20 KPH.

Stop and Search vs Drive Through: 21 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 21 KPH yielding the following: U = 153600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 21 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 21 KPH yielding the following: U = 686080.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 21 KPH.

Stop and Search vs Drive Through: 22 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 22 KPH yielding the following: U = 99200.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 22 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 22 KPH yielding the following: U = 686860.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis

indicates that the "stop and search" procedure is more effective at preventing casualties than the "drive through" procedure at 22 KPH.

Stop and Search vs Drive Through: 23 KPH

A Mann-Whitney U test indicated that strikes were less for "stop and Search" procedure than the "drive through" procedure at 23 KPH yielding the following: U = 85600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective in detecting the IED threat than the drive through model at 23 KPH.

A Mann-Whitney U test indicated that casualties were less for "stop and Search" procedure than the "drive through" procedure at 23 KPH yielding the following: U = 698560.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective at preventing casualties than the "drive through" procedure at 23 KPH.

Stop and Search vs Drive Through: 24 KPH

A Mann-Whitney U test indicated that strikes were less for "stop and Search" procedure than the "drive through" procedure at 24 KPH yielding the following: U = 72000.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop

and search” procedure is more effective in detecting the IED threat than the drive through model at 24 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 24 KPH yielding the following: U = 645520.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 24 KPH.

Statistically 24 KPH proved to be the worse speed in terms of strikes of the entire experiment.

Stop and Search vs Drive Through: 25 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 25 KPH yielding the following: U = 84000.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 25 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 25 KPH yielding the following: U =

665020.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 25 KPH.

Stop and Search vs Drive Through: 26 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 26 KPH yielding the following: U = 97600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 26 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 26 KPH yielding the following: U = 674380.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 26 KPH.

Stop and Search vs Drive Through: 27 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 27 KPH yielding the following: U = 114400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 27 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 27 KPH yielding the following: U = 702460.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 27 KPH.

Stop and Search vs Drive Through: 28 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 28 KPH yielding the following: U = 107200.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop

and search” procedure is more effective in detecting the IED threat than the drive through model at 28 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 28 KPH yielding the following: U = 645520.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 28 KPH.

Stop and Search vs Drive Through: 29 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 29 KPH yielding the following: U = 103200.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 29 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 29 KPH yielding the following: U = 654100.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not

exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 29 KPH.

Stop and Search vs Drive Through: 30 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 30 KPH yielding the following: U = 109600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 30 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 30 KPH yielding the following: U = 689200.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 30 KPH.

Stop and Search vs Drive Through: 31 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 31 KPH yielding the following: U = 118400.000, p = .000

the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 31 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 31 KPH yielding the following: U = 706360.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 31 KPH.

Stop and Search vs Drive Through: 32 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 32 KPH yielding the following: U = 145600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 32 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 32 KPH yielding the following: U = 740680.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 32 KPH

Stop and Search vs Drive Through: 33 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 33 KPH yielding the following: U = 126400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 33 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 33 KPH yielding the following: U = 727420.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis

indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 33 KPH.

Stop and Search vs Drive Through: 34 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 34 KPH yielding the following: U = 128800.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 34 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 34 KPH yielding the following: U = 725080.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 34 KPH.

Stop and Search vs Drive Through: 35 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 35 KPH yielding the following: U = 137600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 35 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 35 KPH yielding the following: U = 737560.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 35 KPH.

Stop and Search vs Drive Through: 36 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 36 KPH yielding the following: U = 129600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 36 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 36 KPH yielding the following: U =

743800.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 36 KPH.

Stop and Search vs Drive Through: 37 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 37 KPH yielding the following: U = 92000.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 37 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 37 KPH yielding the following: U = 718840.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 37 KPH.

Stop and Search vs Drive Through: 38 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 38 KPH yielding the following: U = 110400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 38 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 38 KPH yielding the following: U = 754720.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 38 KPH.

Stop and Search vs Drive Through: 39 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 39 KPH yielding the following: U = 122400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop

and search" procedure is more effective in detecting the IED threat than the drive through model at 39 KPH.

A Mann-Whitney U test indicated that casualties were less for "stop and Search" procedure than the "drive through" procedure at 39 KPH yielding the following: U = 719620.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective at preventing casualties than the "drive through" procedure at 39 KPH.

Stop and Search vs Drive Through: 40 KPH

A Mann-Whitney U test indicated that strikes were less for "stop and Search" procedure than the "drive through" procedure at 40 KPH yielding the following: U = 120000.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the "stop and search" procedure is more effective in detecting the IED threat than the drive through model at 40 KPH.

A Mann-Whitney U test indicated that casualties were less for "stop and Search" procedure than the "drive through" procedure at 40 KPH yielding the following: U = 704020.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not

exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 40 KPH.

Stop and Search vs Drive Through: 41 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 41 KPH yielding the following: U = 128000.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 41 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 41 KPH yielding the following: U = 739120.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 41 KPH.

Stop and Search vs Drive Through: 42 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 42 KPH yielding the following: U = 131200.000, p = .000

the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 42 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 42 KPH yielding the following: U = 733660.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 42 KPH.

Stop and Search vs Drive Through: 43 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 43 KPH yielding the following: U = 133600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 43 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 43 KPH yielding the following: U = 741460.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in preventing casualties than the drive through model at 43 KPH.

Stop and Search vs Drive Through: 44 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 44 KPH yielding the following: U = 128000.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 44 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 44 KPH yielding the following: U = 738340.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis

indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 44 KPH.

Stop and Search vs Drive Through: 45 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 45 KPH yielding the following: U = 125600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 45 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 45 KPH yielding the following: U = 734440.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 45 KPH.

Stop and Search vs Drive Through: 46 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 46 KPH yielding the following: U = 137600.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 46 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 46 KPH yielding the following: U = 765640.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 46 KPH.

Stop and Search vs Drive Through: 47 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 47 KPH yielding the following: U = 136800.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 47 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 47 KPH yielding the following: U =

711040.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 47 KPH.

Stop and Search vs Drive Through: 48 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 48 KPH yielding the following: U = 146400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 48 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 48 KPH yielding the following: U = 765640.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 48 KPH.

Stop and Search vs Drive Through: 49 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 49 KPH yielding the following: U = 134400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective in detecting the IED threat than the drive through model at 49 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 49 KPH yielding the following: U = 770320.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 49 KPH.

Stop and Search vs Drive Through: 50 KPH

A Mann-Whitney U test indicated that strikes were less for “stop and Search” procedure than the “drive through” procedure at 50 KPH yielding the following: U = 134400.000, p = .000 the p-value is less than the .05 threshold therefore we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop

and search” procedure is more effective in detecting the IED threat than the drive through model at 50 KPH.

A Mann-Whitney U test indicated that casualties were less for “stop and Search” procedure than the “drive through” procedure at 50 KPH yielding the following: U = 766420.000, p = .000 the p-value is less than the .05 threshold therefore, we must reject the null hypothesis. The post hoc power level for this test was 1.00, the beta threshold of .20 was not exceed thus the rejection of the null hypotheses is supported. The rejection of the null hypothesis indicates that the “stop and search” procedure is more effective at preventing casualties than the “drive through” procedure at 50 KPH.

In summation, the “stop and search” procedure is statistically more effective in detection of the IED threat than the “drive through” procedure at all tested speeds except for casualties at 10 KPH. If the assumption of a destroyed vehicle equates to all five occupants dying, then the “stop and search” method remains more efficient at 10 KPH. The “stop and search” procedure benefits from one more soldier based sensor as well as a broader search area based on the positions of the sensors on the battle field as compared to the vehicular based “drive through” procedure.

CHAPTER FIVE: SUMMARY

Motivation

The motivation for this research ultimately is an effort to explore two alternative tactical procedures for countering improvised explosive devices deployed during asymmetric warfare in Afghanistan-like rural settings. As previously stated IEDs continue to be the number one casualty producing weapons system on the asymmetric battlefield and will remain so for the near future. Further, field observations of actual units performing the “stop and search” method on a routine basis within the context of asymmetric warfare in rural Afghanistan suffered fewer casualties than their allied counterparts practicing the “drive through” method for a good majority of their tactical movements. The intent and motivation of this research was twofold. First was to verify that the anecdotal observations were not a coincidence, and secondly to fill a gap in research that exists concerning CIED procedures and tactics. The desired outcome of this research is aiding in a very small way, to a viable solution for this complex problem. Ultimately, the overall goal would be reducing strikes, increasing detection rates, and contributing to a significant reduction in casualties. While this research is limited in scope, its basic design is easily expandable allowing for research that is more complex.

Research Design

In comparing the two procedures, two models evolved from a single synthetic natural environment modeled in MAK VR Forces 4.2.2. The environment and objects within the environment are identical. The models differ only in their logic in approaching and searching for the IED. The “Stop and Search” procedure model reacts to a potential danger area and dismounts four soldier based entities to visually clear the suspected danger area. The “drive through” procedure model does not dismount soldiers but instead relies on driver, passenger, and gunner based sensors alone to search for IEDs. In both procedure models, the sensors and sensor capability are identical; however, speed, exposure time, line of sight, and object size all play apart in recognition and detection of the IED threat. Given that the environments are identical, but each model applies a different CIED procedure, the outcomes of strikes and casualties between procedural models are the basis of comparison with respect to detection and casualty efficiencies.

The basis for the “stop and search” model is doctrine in clearance of a danger area from FM 3-21.8 and its observed use by allied units in Afghanistan. The “drive through model” is also representative of doctrine from FM 3-21.8. Both models represent tactical choice available to the on ground commander. Running the “stop and search” procedural model 1600 times at the base speed of 6 KPH and the “drive through” procedural model 1600 times at each speed starting with 10 KPH and ending at 50 KPH in one KPH increments, yields a total of 67,200 runs in which statistical analysis is applied. Each simulation produces a very large set of data. Detonation PDUs and Entity State PDUs provide the variables for appropriate comparative analysis with respect to detection and casualty efficiencies. The following section covers the data collection methodology.

Data Collection

Mak Logger 5.1.3 is the primary data collection tool for this research. The Mak logger tool captures all simulation traffic within VR Forces via DIS or HLA connection and allows it to be either saved as a logger tape format or exported to a SQL database, Access database, or a text file and example portion of the text file is in Appendix D. All simulations were saved in the logger format and exported to the appropriate SQL database. Filtering was accomplished using the SQL query feature found in Microsoft excel.

Data and Analysis Summary

Analysis of the research data accomplished identifying the efficiencies of the procedures by applying a Mann Whitney U test comparing the "stop and search" CIED procedure to the "drive through" CIED procedure for both strikes and casualties at each given speed from 10 KPH to 50 KPH. This statistical testing applied to all 67200 runs. This analysis facilitated the answering of the research question and hypotheses stated below. SPSS v23.0 carried out all statistical testing except for A priori and post hoc power tests in which G*Power 3.1.9.2 provided analysis. All testing is at a 95% confidence interval with the A priori and post hoc testing not exceeding a .20 beta level. The A priori ensured that the sample size was large enough while the post hoc testing aided in controlling type I and type II errors. The analysis section of this research answered the following questions:

Research Question: Is the "stop and search" procedure more effective in IED detection and casualty prevention than the "drive through" procedure?

Hypothesis:

H0: "Stop and Search" CIED procedure is equally as effective as the "drive through" CIED procedure at detecting the IED threat.

Ha: “Stop and Search” CIED procedure is more effective in detecting the IED threat to that of the “drive through” CIED procedure.

H0: “Stop and Search” CIED procedure is equally as effective as the “drive through” CIED procedure preventing casualties.

Ha: “Stop and Search” CIED procedure is more effective at preventing casualties to that of the “drive through” CIED procedure.

Appendix E contains statistical output for each set of runs. Table 1 summarizes the statistical outcomes for each set of runs. The first column S & S represents the “stop and search” procedure while the second represents the “drive through” procedure at the given speed. Figure 5 located in the previous chapter displays the frequency of outcomes in a graphical format. The “stop and search” is more efficient in both strikes and casualties than the “drive through” procedure at all tested speeds except for casualties at 10 KPH as previously noted. Regression data further shows that increasing speed does not intercept “stop and search” model strikes and casualties until 749 KPH and 196 KPH respectively.

Conclusion

This research and the test results indicate that the “stop and search” procedure reflective of the doctrine covered in FM 3-21.8 is more effective than the “drive through” procedure. The “stop and search” model proved significantly more effective when compared to the drive through model at any given speed except for vehicles destroyed/casualties at 10 KPH. This research is limited in that it tests a “best case” scenario the results have indicated that procedural choice in respect to CIED has consequences. This research illustrates the need to investigate not only the technological solution but the procedural as well. Though this research and experiment scope were limited by time and funding, it can be easily expanded to include more complex scenarios and further the realism of sensor capability with the addition of pug-ins for the software. The simplicity of this experiment does not diminish the potential of using procedures as an effective mechanism for reducing both strikes and casualties.

There is without a doubt large amounts of funding for research and development of technology aimed at countering the asymmetric use of IEDs in battlefields like Afghanistan or Iraq. Literally billions of dollars have funded attempts to rectify this persistent problem. One might ask, for all of the monumental effort in trying to design and create technological countermeasures, has the same focus and effort been expended on doctrine, tactical choice, and procedures as countermeasures? This analysis supports the notion that doctrine, tactical choice and procedure as countermeasures are worthy of at least equal emphasis. Further, while there are programs and equipment being developed to improve detection of soldiers, current and future equipment sets challenge the usefulness these skills by negating some to the tactical choice. The mine roller is an example of a piece of equipment that supports the use of the “drive through” procedure. In addition to this negative tradeoff of sacrificing higher cost mine roller for a lower cost IED, another potential issue is regular usage of such equipment may create reliance on the equipment and degrade the critical skills of soldier based visual detection. Historically, in the U.S. military, there have been instances that in the presence of new technology loss of basic fighting skills have occurred with devastating consequences.

The Iran Air Flight 655 is an example of this in that the USS Vincennes shot down a civilian airliner. The ship was equipped with the Aegis Combat System. This state of the art newly deployed combat system had a number of flaws including a poor user interface. The crews reliance on this system and its poor interface ultimately led to a poor decision an ultimately led to 290 civilian deaths, due to the misidentification of an aircraft by USS Vincennes Agis system and crew interpretation of presented data (Dotterway, 1992).

The recent capture of two naval patrol vessels by Iran highlights another such instance. The reliance on GPS within the military has increased dramatically over time (Morgan, 2012). Such reliance on a technology can lead to traditional skills perishing over time. While GPS is a technological marvel, technology already exist to disrupt or fool devices by feeding them false signals (Morgan, 2012). While the capture of the naval vessels based on nefarious signals causing the onboard GPS to display incorrect information is only speculative, it does highlight the need to maintain a traditional skill set. If GPS spoofing did occur, tracking navigational progress via chart, heading, and speed may have at least alerted the crew to a problem.

Limitations and Future Research

There are significant limitations to this research. First, the research evaluates a patrol, not a convoy, encountering a single IED, not a complex ambush with multiple IEDs and kill zones. Further, the model represents a surface laid IED, which is arguably easier to spot than a buried one. Route, road materials, road representations (e.g. straight, curved, incline, declines, gravel, paved, etc.) are also limitations as there are a plethora of combinations of these attributes and associated scenarios that can be tested and provide useful information. The main limitation of this research is the use of one scenario. For instance in some conditions such as a mountain road with cliffs and rough terrain visual clearance techniques described within this research may not be totally feasible and have to be modified to accomplish the desired end state. The methodology set forth in this research however, is appropriate to test scenario and material variations, given the time to do the analysis. A scanning feature for the human based entities is lacking within this research. While a frustum representing the visual field is present and in accordance with MIL STD 1472G, a scanning algorithm would likely increase the correlation between the simulation and live testing.

Appropriate future research may include convoys, complex ambushes, buried IEDs, IEDs of different explosive potential and different explosive types. Further, operations of friendly forces may vary by speed and vehicle type. Implicitly higher speeds reduce both danger area and IED detection ability. More complex operations may provide insight into the impact of complex enemy ambushes and the effects on the scenario described above. This may be mitigated by friendly UAV's used to detect potential complex ambushes (Hakola, 2004). Urban operations may also be modeled with civilian causalities monitored. This research also provides the basis for future live testing in which real world results are collected and analyzed. Future research should also include the Common Remotely Operated Weapon Station or CROWS II and its effects on detection. With the CROWS weapons platform already fielded to some units, the gunner position moves inside the vehicle to a remote viewing station. This in turn removes a set of soldier based optical sensors from the battlefield. Given the results of this experiment, the Crows system has the potential to affect the ability to detect danger areas with appropriate standoff and warrants further research.

APPENDIX A: PRE-DEPLOYMENT TRAINING (Crawford, 2009, p. 33)

Required Tasks by Deployment Category

CAT 1 — Contingency Operating Base/Forward Operating Base Units

Units that would rarely, if ever, travel off a COB/FOB

such as Theater Support: Kuwait, Qatar, Bahrain, etc.

Individual Soldier Tasks (60 Tasks)

- Complete Army Warrior Tasks (32 Tasks)
- Qualify with Assigned Weapon
- Complete Basic First Aid (11 Tasks)
- Conduct HMMWV Rollover Training
- Complete Hot and Cold Weather Training
- Conduct Desert Environment Training
- Complete Mine Awareness Training
- Complete Level 1 Antiterrorism Awareness Training
- Complete Regulatory Briefings (General Orders, OPSEC/SAEDA, Equal Opportunity, Prevent Sexual Harassment/Assault, DA Fraternization Policy, Army Values and Ethics
- Identify Combat Stress & Suicide Prevention (including Battlemind, MTBI, PTSD)
- Conduct Personnel Recovery Training
- Conduct Law of War Training
- Complete Rules of Engagement Training
- Complete Rules for Use of Force (RUF) Training
- Complete Biometrics Training
- Complete Trafficking in Persons Brief
- Complete Media Awareness Training
- Complete Country Orientation Brief
- Complete Basic Language/Culture Training

Individual Leader Tasks

- Complete Theater Briefing (Military, Culture, Economic, Religious, Political)
- Complete Level 2 Antiterrorism Awareness Training
- Conduct Casualty and Medical Evacuation
- Complete Application and Uses of Biometrics Training
- Incorporate Personnel Recovery Planning
- Complete Identify/Mitigate Combat Stress
- Complete Suicide Prevention Brief
- Supervise Proper Field Sanitation
- Individual IED Defeat Leader Tasks
- Utilize an Interpreter

Collective Tasks

- Execute Army Warrior Training Battle Drills (12 Tasks)
- Execute Culminating Training Event

CAT 2 — COB/FOB Units w/Travel Off Base (* Includes All CAT 1 Tasks)

Units that will or potentially will travel for short duration off a COB/FOB

such as Light/Medium Truck Company, Horn of Africa, Guantanamo Bay, Civil Affairs/Psychological Operations, Postal, Combat Support Hospital, Detainee Operations

Additional Individual Soldier Tasks
Expanded IED Defeat Training

- Identify Visual Indicators of an IED
- React to a Possible IED
- React to an IED Attack or Vehicle Borne IED
- React to an IED initiated Chemical Attack
- Prepare for IED Threats Prior to Movement
- Employ Man-Pack and Vehicular-mounted Electronic Warfare Device
- Perform a 9-line UXO/IED Explosive Hazard Spot Report
- Plan for IED Threats

Additional Individual Leader Tasks

- Conduct Call for Fire
- Supervise Convoy Operations
- Complete Media Engagement Training
- Supervise Traffic Control Points
- Supervise Handling of Enemy Personnel and Equip
- Conduct PCCs / PCIs of Combat Patrols
- Supervise Application of ROE/Graduated Response

Additional Collective Tasks

- Conduct Live Fire Exercises
- Execute Convoy Operations (including Crew Training)
- Complete IEDD Collective Tasks (11 Tasks)
- Maintain Base Camp Defense and Security
- Execute Culminating Training Event

CAT 3 — Units Conducting Mission Off COB/FOB (* Includes All CAT 1 and 2 Tasks)

Units that will travel and conduct majority of missions off a COB/FOB

such as Security Force, Provincial Reconstruction Team, Afghan National Army, Light/Medium Truck Company (Self Secure), Engineer, Route Clearance, Military Police Police Transitional Team

Additional Individual Leader Tasks

- Perform Negotiations
- Plan and Conduct Urban Operations (OIF)
- Plan and Conduct Mountainous Operations (OEF)
- Conduct Crowd Control

Additional Collective Tasks

- Conduct Live Fire Exercises
- Coordinate With Coalition Forces
- Execute Culminating Training Event

CAT 4 — Maneuver Units (* Includes All CAT 1, 2, and 3 Tasks)

Maneuver Units with an AE, newly formed units, units on a constrained deploy timeline

such as Brigade Combat Team, Counterinsurgency Operations

Additional Individual Leader Tasks

- IED-Defeat Training—Plan for IED Threats
- Senior Leader Orientation Training

Additional Collective Tasks

- Nonlethal Weapons Capabilities Training
- Execute Culminating Training Event

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Legend:

- BCT - brigade combat team
- CA - civil affairs
- CSH - combat support hospital
- DA - Department of the Army
- Det Ops- detainee operations
- GTMO - Guantanamo Bay
- HOA - Horn of Africa
- MTBI - mild traumatic brain injury
- OEF - Operation Enduring Freedom
- OIF - Operation Iraqi Freedom
- OPSEC - operations security
- PCC - precombat check
- PCI - precombat inspection
- PSYOP - psychological operations
- PTSD - post-traumatic stress disorder
- ROE - rules of engagement
- SAEDA - subversion and espionage directed against the Army
- SECFOR - security force
- UXO - unexploded ordnance

APPENDIX B: SENSOR FILES

Default Sensor

```
(visual-sensor-system
  (systems )
  (sensors
    (visual-sensor
      (component-descriptor-type "signature-sensor-descriptor")
      (component-type  "signature-sensor")
      (min-tick-period  2.000000)
      (min-tick-period-variance  0.100000)
      (tick-period-uses-real-time False)
      (process-state-repository-name  "")
      (process-state-repository-type  "")
      (is-enabled True)
      (detect-only-hostile-forces False)
      (detection-types )
      (detect-destroyed-objects False)
      (sensor-geometry
        (in-range
          (range $max-range)
        )
      )
      (sensor-domain  "visual")
      (sensor-offset $sensor-position)
      (sensor-positional-error  0.000000)
      (detection-level-determinator
        (determinator-type  "signature-detection-level-determinator")
        (detection-level-to-set-hostility  3)
        (combat-identification-level-table-file
          (filename  "$(detection-dir)\std-visual-detection-table.csv")
        )
      )
    )
  )
  (controllers )
  (actuators )
  (connections
    (connect system:object-types-to-detect visual-sensor:object-types-to-detect)
    (connect visual-sensor:detected-objects system:detected-objects)
    (connect system:sensor-offset visual-sensor:sensor-offset)
  )
  (resources )
  (meta-data
    (system-name  "Visual Sensor")
```

```
    (system-description  "Allows an entity to detect other objects through visible light.")
    (allowed-state-repository-types "all")
    (system-categories "sensor")
    (parameter-data-list
      (vector-parameter-data
        (parameter-name  "sensor-position")
        (variable-type  "DtRwOffsetVector")
        (display-label  "Sensor Location")
        (display-units  "meters")
        (source-units  "meters")
        (default-value  0.000000 0.000000 0.000000)
        (relative-to  "")
      )
      (real-parameter-data
        (parameter-name  "max-range")
        (variable-type  "DtRwReal")
        (display-label  "Maximum Range")
        (display-units  "meters")
        (source-units  "meters")
        (default-value  4000.000000)
      )
    )
    (meta-data-entry-list
      (detect-object-types-input
        (detect-object-types-input-port-name  "object-types-to-detect")
      )
      (detected-objects-output
        (detected-objects-output-port-name  "detected-objects")
      )
    )
  )
)
```

Modified Human Sensor File

```
(visual-sensor-system
  (systems )
  (sensors
    (visual-sensor
      (component-descriptor-type "signature-sensor-descriptor")
      (component-type  "signature-sensor")
      (min-tick-period  2.000000)
      (min-tick-period-variance  0.100000)
      (tick-period-uses-real-time False)
      (process-state-repository-name  "")
      (process-state-repository-type  "")
      (is-enabled True)
      (detect-only-hostile-forces False)
      (detection-types
                (entity-type 1 (2 2 0 3 1 1 0))
                (entity-type 9 (5 1 0 5 17 3 0))
           )
      (detect-destroyed-objects False)
      (sensor-geometry
        (and
          (in-frustum
            (el-max 1.151917) ;; 60 degrees in az and 66 up and 35 down MIL STD 1472G for
head rotation
            (el-min -0.610865)
            (az-max 1.0472)
            (az-min -1.0472)
          )
          (in-range
            (range $max-range)
          )
        )
      )
      (sensor-domain  "visual")
      (sensor-offset $sensor-position)
      (sensor-positional-error  0.000000)
      (detection-level-determinator
        (determinator-type  "signature-detection-level-determinator")
        (detection-level-to-set-hostility  3)
        (combat-identification-level-table-file
          (filename  "$(detection-dir)\std-visual-detection-table.csv")
        )
      )
```

```
    )
  )
  (controllers )
  (actuators )
  (connections
    (connect system:object-types-to-detect visual-sensor:object-types-to-detect)
    (connect visual-sensor:detected-objects system:detected-objects)
    (connect system:sensor-offset visual-sensor:sensor-offset)
  )
  (resources )
  (meta-data
    (system-name  "Human Sensor")
    (system-description  "Allows an entity to detect other objects through visible light.")
    (allowed-state-repository-types "all")
    (system-categories "sensor")
    (parameter-data-list
      (vector-parameter-data
        (parameter-name  "sensor-position")
        (variable-type  "DtRwOffsetVector")
        (display-label  "Sensor Location")
        (display-units  "meters")
        (source-units  "meters")
        (default-value  0.000000 0.000000 0.000000)
        (relative-to  "")
      )
      (real-parameter-data
        (parameter-name  "max-range")
        (variable-type  "DtRwReal")
        (display-label  "Maximum Range")
        (display-units  "meters")
        (source-units  "meters")
        (default-value  4000.000000)
      )
    )
    (meta-data-entry-list
      (detect-object-types-input
        (detect-object-types-input-port-name  "object-types-to-detect")
      )
      (detected-objects-output
        (detected-objects-output-port-name  "detected-objects")
      )
    )
  )
)
```

APPENDIX C: MODEL PLANS

Drive Through Procedure

```
Plan for SmWhel
SmWhel 1
If (Detect Entity "IED-Artill1" with identification of at least "Detected ,,") then
  When (NOT(Detect Entity "IED-Artill1" with identification of at least "Detected ,,"))do
   Restart Plan: Name: SmWhel 1
endwhen
else
  When (Detect Entity "IED-Artill1" with identification of at least "Detected ,,") do
    Wait
  endwhen
  Move-Along Route: "Route 3"
endif
```

<u>Stop and Search Model</u>

```
Plan for SmWhel
SmWhel 1
If (Detect Entity "Box 3" with identification of at least "Identified ,,") then
  When (NOT(Detect Entity "Box 3" with identification of at least "Identified ,,")) do
     Restart Plan: Name: SmWhel 1
  endwhen
  If (Entity-Embarked ,ANY, Entity:"DI 1") then
      Send Text Message to: DI 1, "Disembark"
  endif
else
 When (Detect Entity "Box 3" with identification of at least "Identified ,,") do Restart Plan:
Name: SmWhel 1
  endwhen
  Move-Along Route: "Route 3"
Endif


Plan for DI
DI 1
 When (Receive text message matching "Disembark") do
   Task Object R 2 Task: Disembark-Entity
   Task Object R 1 Task: Disembark-Entity
   Task Object R 3 Task: Disembark-Entity
   Task Object R 4 Task: Disembark-Entity
  When (AND(AND(AND(NOT(Entity-Embarked ,, Entity:"R 1"), NOT(Entity-Embarked ,,
Entity:"R 2")), NOT(Entity-Embarked ,, Entity:"R 3")),
    Move into formation: formation: Vee loc: {-0.003511, -0.000550, 2}heading: 0.0 (Deg)
    When (Receive text message matching "IED Detected") do
      Wait
   endwhen
  Patrol-Along Route: "Route 3" endwhen
 endwhen


Plan for R 1 page 1
R 1
When (Detect Entity "IED-Artill1" with identification of at least "Detected ,,") do
 Wait
endwhen
```

Radio When IED Detected

```
-- This script template has each of the script entry point functions.
-- They are described in detail in VR-Forces Configuration Guide.

-- Some basic VRF Utilities defined in a common module.
require "vrfutil"

-- Global Variables. Global variables get saved when a scenario gets checkpointed.
-- They get re-initialized when a checkpointed scenario is loaded.

-- Task Parameters Available in Script


-- Called when reactive task is enabled or changes to the enabled state.
function checkInit()
-- Set the tick period for this script while checking.
vrf:setTickPeriod(0.5) end

-- Called each tick period for this script while enabled but not in the active state.
function check()
-- Returning true will cause the reactive task to become active and will call init()
-- and tick() until the task completes.

local contacts = this:getAllContacts()

for idx,contact in pairs(contacts) do
if vrf:entityTypeMatches(contact:getEntityType(), EntityType.Munition()) then return true
end end

return false end

-- Called when the task first starts. Never called again.
function init()
-- Set the tick period for this script.
vrf:setTickPeriod(0.5) end

-- Called each tick while this task is active.
function tick()

local agg = vrf:getSimObjectByName("DI 1") vrf:sendMessage(agg, "IED Detected")
```

```
-- endTask() causes the current task to end once the current tick is complete. tick() will not be
called again.
-- Wrap it in an appropriate test for completion of the task.
vrf:endTask(true) end


-- Called when this task is being suspended, likely by a reaction activating.
function suspend()
-- By default, halt all subtasks and other entity tasks started by this task when suspending.
vrf:stopAllSubtasks() vrf:stopAllTasks()
end

-- Called when this task is being resumed after being suspended.
function resume()
-- By default, simply call init() to start the task over.
init() end
-- Called immediately before a scenario checkpoint is saved when
-- this task is active.
-- It is typically not necessary to add code to this function.
function saveState() end

-- Called immediately after a scenario checkpoint is loaded in which
-- this task is active.
-- It is typically not necessary to add code to this function.
function loadState() end

-- Called when this task is ending, for any reason.
-- It is typically not necessary to add code to this function.
function shutdown() end

-- Called whenever the entity receives a text report message while
-- this task is active.
--   message is the message text string.
-- sender is the SimObject which sent the message. function receiveTextMessage(message,
sender) end
```

APPENDIX D: LOGGER OUTPUT SAMPLE

Entity State PDU

```
**********************************************************************************
**** Packet #5     Size=208    time=0:00:00.1696, 18:54:24.9986 Fri Oct 23, 2015
******** Type=PDU #3        ****************************************************
PduKind:            EntityStatePduKind   (1)
Version:            5
Exercise:           1
ProtocolFamily:     FamilyEntityInteraction (1)
TimeStamp:          3264.98
TimeStampType:      Relative
Size:               208
----------------------------------------
EntityId:           1:3001:2
EntityType:         1:1:225:6:1:18:0
ForceID:            ForceFriendly (1)
Location:           {6378138.787991, -59.869135, -396.560779}
Velocity:           {0.000000, 0.000000, 0.000000}
Acceleration:       {0.000000, 0.000000, 0.000000}
Orientation:        {3.141583, -1.541213, 3.138483}
AngularVel:         {0.000000, 0.000000, 0.000000}
DrAlgorithm:        DrDrmRvw (4)
NumArtParams:       4
NumAttachedParts:   0
Guise:              1:1:225:6:1:18:0
Appearance:         6291456
PaintScheme:        0
Immobilized:        FALSE
FirePowerKill:      FALSE
DamageState:        DamageNone (0)
EngineSmoke:        FALSE
SmokePlume:         FALSE
TrailState:         TrailingEffectsNone (0)
HatchState:         HatchNA (0)
LightState:         LightsNone (0)
Flames:             FALSE
Frozen:             TRUE
PowerPlant:         TRUE
FinalPdu:           FALSE
LauncherRaised:     FALSE
CamouflageType:     DesertCamouflage (0)
Concealed:          FALSE
Tent:               FALSE
Ramp:               FALSE
Marking:            SmWhel 1
CharSet:            1
Capabilities:       0
[Change=0, AttachedTo=0, Type=4107, Value = 0, 0]
[Change=0, AttachedTo=0, Type=4108, Value = 0, 0]
[Change=0, AttachedTo=1, Type=4429, Value = 0, 0]
[Change=0, AttachedTo=1, Type=4430, Value = 0, 0]
```

Detonation State PDU

```
********************************************************************************
**** Packet #9864   Size=104    time=0:01:16.7002, 18:55:41.5292 Fri Oct 23, 2015
******** Type=PDU #9860      ***************************************************
PduKind:            DetonationPduKind   (3)
Version:            5
Exercise:           1
ProtocolFamily:       FamilyWarfare (2)
TimeStamp:           3341.51
TimeStampType:        Relative
Size:               104
----------------------------------------
From::              1:3001:97
Target::            0:0:0
Munition::            1:3001:97
Event::             1:3001:4
WorldLocation::       {6378138.144046, -40.628671, -306.916550}
Velocity::            {0.000000, 0.000000, 0.000000}
Result::            DetResDetonation (5)
FuseType::            FuzeProximity (3000)
MunitionType::        2:9:225:2:14:2:1
Quantity::            1
Rate::              0
WarheadType::         WarheadOther (0)
EntityLocation::      {0.000000, 0.000000, 0.000000}
 Art Parts:
```

APPENDIX E: MANN WHITNEY U-TEST RESULTS STOP AND SEARCH VS GIVEN SPEED

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1564.50	2503200.00
	10 KPH	1600	1636.50	2618400.00
	Total	3200		
Casualties	Stop and Search	1600	1590.05	2544080.00
	10 KPH	1600	1610.95	2577520.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	1222400.000	1263280.000
Wilcoxon W	2503200.000	2544080.000
Z	-5.282	-1.776
Asymp. Sig. (2-tailed)	.000	.076

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1489.50	2383200.00
	11KPH	1600	1711.50	2738400.00
	Total	3200		
Casualties	Stop and Search	1600	1558.85	2494160.00
	11KPH	1600	1642.15	2627440.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	1102400.000	1213360.000
Wilcoxon W	2383200.000	2494160.000
Z	-12.604	-5.957
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1447.00	2315200.00
	12KPH	1600	1754.00	2806400.00
	Total	3200		
Casualties	Stop and Search	1600	1530.58	2448920.00
	12KPH	1600	1670.43	2672680.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	1034400.000	1168120.000
Wilcoxon W	2315200.000	2448920.000
Z	-15.863	-8.934
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1389.50	2223200.00
	13KPH	1600	1811.50	2898400.00
	Total	3200		
Casualties	Stop and Search	1600	1505.23	2408360.00
	13KPH	1600	1695.78	2713240.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	942400.000	1127560.000
Wilcoxon W	2223200.000	2408360.000
Z	-19.799	-11.235
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1347.00	2155200.00
	14KPH	1600	1854.00	2966400.00
	Total	3200		
Casualties	Stop and Search	1600	1475.98	2361560.00
	14KPH	1600	1725.03	2760040.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	874400.000	1080760.000
Wilcoxon W	2155200.000	2361560.000
Z	-22.496	-13.613
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1221.00	1953600.00
	15KPH	1600	1980.00	3168000.00
	Total	3200		
Casualties	Stop and Search	1600	1417.48	2267960.00
	15KPH	1600	1783.53	2853640.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	672800.000	987160.000
Wilcoxon W	1953600.000	2267960.000
Z	-29.992	-17.815
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1185.00	1896000.00
	16KPH	1600	2016.00	3225600.00
	Total	3200		
Casualties	Stop and Search	1600	1387.74	2220380.00
	16KPH	1600	1813.26	2901220.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	615200.000	939580.000
Wilcoxon W	1896000.000	2220380.000
Z	-32.080	-19.770
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1082.50	1732000.00
	17KPH	1600	2118.50	3389600.00
	Total	3200		
Casualties	Stop and Search	1600	1339.96	2143940.00
	17KPH	1600	1861.04	2977660.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	451200.000	863140.000
Wilcoxon W	1732000.000	2143940.000
Z	-38.077	-22.753
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	1058.00	1692800.00
	18KPH	1600	2143.00	3428800.00
	Total	3200		
Casualties	Stop and Search	1600	1314.61	2103380.00
	18KPH	1600	1886.39	3018220.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	412000.000	822580.000
Wilcoxon W	1692800.000	2103380.000
Z	-39.541	-24.281
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	964.50	1543200.00
	19KPH	1600	2236.50	3578400.00
	Total	3200		
Casualties	Stop and Search	1600	1275.13	2040200.00
	19KPH	1600	1925.88	3081400.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	262400.000	759400.000
Wilcoxon W	1543200.000	2040200.000
Z	-45.328	-26.612
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	934.00	1494400.00
	20KPH	1600	2267.00	3627200.00
	Total	3200		
Casualties	Stop and Search	1600	1258.06	2012900.00
	20KPH	1600	1942.94	3108700.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	213600.000	732100.000
Wilcoxon W	1494400.000	2012900.000
Z	-47.305	-27.605
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	896.50	1434400.00
	21KPH	1600	2304.50	3687200.00
	Total	3200		
Casualties	Stop and Search	1600	1229.30	1966880.00
	21KPH	1600	1971.70	3154720.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	153600.000	686080.000
Wilcoxon W	1434400.000	1966880.000
Z	-49.815	-29.269
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	862.50	1380000.00
	22KPH	1600	2338.50	3741600.00
	Total	3200		
Casualties	Stop and Search	1600	1229.79	1967660.00
	22KPH	1600	1971.21	3153940.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	99200.000	686860.000
Wilcoxon W	1380000.000	1967660.000
Z	-52.176	-29.241
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	854.00	1366400.00
	23KPH	1600	2347.00	3755200.00
	Total	3200		
Casualties	Stop and Search	1600	1237.10	1979360.00
	23KPH	1600	1963.90	3142240.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	85600.000	698560.000
Wilcoxon W	1366400.000	1979360.000
Z	-52.781	-28.819
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	845.50	1352800.00
	24KPH	1600	2355.50	3768800.00
	Total	3200		
Casualties	Stop and Search	1600	1203.95	1926320.00
	24KPH	1600	1997.05	3195280.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	72000.000	645520.000
Wilcoxon W	1352800.000	1926320.000
Z	-53.392	-30.729
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	853.00	1364800.00
	25KPH	1600	2348.00	3756800.00
	Total	3200		
Casualties	Stop and Search	1600	1216.14	1945820.00
	25KPH	1600	1984.86	3175780.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	84000.000	665020.000
Wilcoxon W	1364800.000	1945820.000
Z	-52.853	-30.028
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	861.50	1378400.00
	26KPH	1600	2339.50	3743200.00
	Total	3200		
Casualties	Stop and Search	1600	1221.99	1955180.00
	26KPH	1600	1979.01	3166420.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	97600.000	674380.000
Wilcoxon W	1378400.000	1955180.000
Z	-52.247	-29.691
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	872.00	1395200.00
	27KPH	1600	2329.00	3726400.00
	Total	3200		
Casualties	Stop and Search	1600	1239.54	1983260.00
	27KPH	1600	1961.46	3138340.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	114400.000	702460.000
Wilcoxon W	1395200.000	1983260.000
Z	-51.508	-28.678
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	867.50	1388000.00
	28KPH	1600	2333.50	3733600.00
	Total	3200		
Casualties	Stop and Search	1600	1203.95	1926320.00
	28KPH	1600	1997.05	3195280.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	107200.000	645520.000
Wilcoxon W	1388000.000	1926320.000
Z	-51.823	-30.729
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	865.00	1384000.00
	29KPH	1600	2336.00	3737600.00
	Total	3200		
Casualties	Stop and Search	1600	1209.31	1934900.00
	29KPH	1600	1991.69	3186700.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	103200.000	654100.000
Wilcoxon W	1384000.000	1934900.000
Z	-52.000	-30.420
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	869.00	1390400.00
	30KPH	1600	2332.00	3731200.00
	Total	3200		
Casualties	Stop and Search	1600	1231.25	1970000.00
	30KPH	1600	1969.75	3151600.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	109600.000	689200.000
Wilcoxon W	1390400.000	1970000.000
Z	-51.718	-29.157
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	874.50	1399200.00
	31KPH	1600	2326.50	3722400.00
	Total	3200		
Casualties	Stop and Search	1600	1241.98	1987160.00
	31KPH	1600	1959.03	3134440.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	118400.000	706360.000
Wilcoxon W	1399200.000	1987160.000
Z	-51.333	-28.537
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	891.50	1426400.00
	32KPH	1600	2309.50	3695200.00
	Total	3200		
Casualties	Stop and Search	1600	1263.43	2021480.00
	32KPH	1600	1937.58	3100120.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	145600.000	740680.000
Wilcoxon W	1426400.000	2021480.000
Z	-50.157	-27.294
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	879.50	1407200.00
	33KPH	1600	2321.50	3714400.00
	Total	3200		
Casualties	Stop and Search	1600	1255.14	2008220.00
	33KPH	1600	1945.86	3113380.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	126400.000	727420.000
Wilcoxon W	1407200.000	2008220.000
Z	-50.985	-27.775
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	881.00	1409600.00
	34KPH	1600	2320.00	3712000.00
	Total	3200		
Casualties	Stop and Search	1600	1253.68	2005880.00
	34KPH	1600	1947.33	3115720.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	128800.000	725080.000
Wilcoxon W	1409600.000	2005880.000
Z	-50.881	-27.860
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	886.50	1418400.00
	35KPH	1600	2314.50	3703200.00
	Total	3200		
Casualties	Stop and Search	1600	1261.48	2018360.00
	35KPH	1600	1939.53	3103240.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	137600.000	737560.000
Wilcoxon W	1418400.000	2018360.000
Z	-50.500	-27.407
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	881.50	1410400.00
	36KPH	1600	2319.50	3711200.00
	Total	3200		
Casualties	Stop and Search	1600	1265.38	2024600.00
	36KPH	1600	1935.63	3097000.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	129600.000	743800.000
Wilcoxon W	1410400.000	2024600.000
Z	-50.846	-27.180
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	858.00	1372800.00
	37KPH	1600	2343.00	3748800.00
	Total	3200		
Casualties	Stop and Search	1600	1249.78	1999640.00
	37KPH	1600	1951.23	3121960.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	92000.000	718840.000
Wilcoxon W	1372800.000	1999640.000
Z	-52.496	-28.086
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	869.50	1391200.00
	38KPH	1600	2331.50	3730400.00
	Total	3200		
Casualties	Stop and Search	1600	1272.20	2035520.00
	38KPH	1600	1928.80	3086080.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	110400.000	754720.000
Wilcoxon W	1391200.000	2035520.000
Z	-51.683	-26.782
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	877.00	1403200.00
	39KPH	1600	2324.00	3718400.00
	Total	3200		
Casualties	Stop and Search	1600	1250.26	2000420.00
	39KPH	1600	1950.74	3121180.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	122400.000	719620.000
Wilcoxon W	1403200.00 0	2000420.00 0
Z	-51.158	-28.058
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	875.50	1400800.00
	40KPH	1600	2325.50	3720800.00
	Total	3200		
Casualties	Stop and Search	1600	1240.51	1984820.00
	40KPH	1600	1960.49	3136780.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	120000.000	704020.000
Wilcoxon W	1400800.000	1984820.000
Z	-51.263	-28.622
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	880.50	1408800.00
	41KPH	1600	2320.50	3712800.00
	Total	3200		
Casualties	Stop and Search	1600	1262.45	2019920.00
	41KPH	1600	1938.55	3101680.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	128000.000	739120.000
Wilcoxon W	1408800.000	2019920.000
Z	-50.915	-27.350
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	882.50	1412000.00
	42KPH	1600	2318.50	3709600.00
	Total	3200		
Casualties	Stop and Search	1600	1259.04	2014460.00
	42KPH	1600	1941.96	3107140.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	131200.000	733660.000
Wilcoxon W	1412000.000	2014460.000
Z	-50.777	-27.549
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	884.00	1414400.00
	43KPH	1600	2317.00	3707200.00
	Total	3200		
Casualties	Stop and Search	1600	1263.91	2022260.00
	43KPH	1600	1937.09	3099340.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	133600.000	741460.000
Wilcoxon W	1414400.000	2022260.000
Z	-50.673	-27.265
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	880.50	1408800.00
	44KPH	1600	2320.50	3712800.00
	Total	3200		
Casualties	Stop and Search	1600	1261.96	2019140.00
	44KPH	1600	1939.04	3102460.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	128000.000	738340.000
Wilcoxon W	1408800.000	2019140.000
Z	-50.915	-27.379
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	879.00	1406400.00
	45KPH	1600	2322.00	3715200.00
	Total	3200		
Casualties	Stop and Search	1600	1259.53	2015240.00
	45KPH	1600	1941.48	3106360.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	125600.000	734440.000
Wilcoxon W	1406400.000	2015240.000
Z	-51.019	-27.520
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	886.50	1418400.00
	46KPH	1600	2314.50	3703200.00
	Total	3200		
Casualties	Stop and Search	1600	1279.03	2046440.00
	46KPH	1600	1921.98	3075160.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	137600.000	765640.000
Wilcoxon W	1418400.000	2046440.000
Z	-50.500	-26.383
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	886.00	1417600.00
	47KPH	1600	2315.00	3704000.00
	Total	3200		
Casualties	Stop and Search	1600	1244.90	1991840.00
	47KPH	1600	1956.10	3129760.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	136800.000	711040.000
Wilcoxon W	1417600.000	1991840.000
Z	-50.535	-28.368
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	892.00	1427200.00
	48KPH	1600	2309.00	3694400.00
	Total	3200		
Casualties	Stop and Search	1600	1279.03	2046440.00
	48KPH	1600	1921.98	3075160.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	146400.000	765640.000
Wilcoxon W	1427200.000	2046440.000
Z	-50.123	-26.383
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	884.50	1415200.00
	49KPH	1600	2316.50	3706400.00
	Total	3200		
Casualties	Stop and Search	1600	1281.95	2051120.00
	49KPH	1600	1919.05	3070480.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	134400.000	770320.000
Wilcoxon W	1415200.000	2051120.000
Z	-50.638	-26.212
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

Mann-Whitney Test

Ranks

	Model	N	Mean Rank	Sum of Ranks
Strike	Stop and Search	1600	884.50	1415200.00
	50KPH	1600	2316.50	3706400.00
	Total	3200		
Casualties	Stop and Search	1600	1279.51	2047220.00
	50KPH	1600	1921.49	3074380.00
	Total	3200		

Test Statistics[a]

	Strike	Casualties
Mann-Whitney U	134400.000	766420.000
Wilcoxon W	1415200.000	2047220.000
Z	-50.638	-26.355
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Model

REFERENCES

Adamson, W. G. (2007). An Asymmetric Threat Invokes Strategic Leader Initiative: The Joint Improvised Explosive Device Defeat Organization: The Industrial College of the Armed Forces, National Defense University.

Archives, N. (Writer) & W. Disney (Director). (1943). Booby Traps [Digital]. In W. Department (Producer), *PVT SNAFU*. Washinton D.C.: War Department.

Army Ammunition Data Sheets: Artillery Ammunition Guns, Howitzers, Mortars, Recoilless Rifles, Grenatde Launchers, and Artillery Fuzes (FSC 1310, 1315, 1320, 1390). (1994). Washington D.C.: Headquarters, Department of Army.

Atkinson, R. (2007). When 'Physics Gets in the Way'. *Washington Post*. Retrieved from http://www.washingtonpost.com/wp-dyn/content/article/2007/10/01/AR2007100101896_2.html?sid=ST2007092900754

Benson, C. M. (2012). *Detecting Improvised Explosive Devices: Enduring Threat Requires Enduring Solutions*. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA560881

Byford, G. J. (2010). *COUNTER Improvised Explosive Device (C-IED) Operations as an Element of Counter Insurgency (COIN): Balancing C-IED Efforts to Support Commander International Security Assistance Force (COMISAF) Operational Objectives*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a535553.pdf

Carr, W. G. (2011). *Defeating the IED: JIEDDO's Mission Impossible, the Lure of Technology, and the Emergence of the COIN Solution*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a600565.pdf

Cary, P., & Youssef, N. (2011 updated 2014, 15 Mar 15). JIEDDO: The Manhattan Project that Bombed. *The Center for Public Integrity*. Retrieved from http://www.publicintegrity.org/2011/03/27/3799/jieddo-manhattan-project-bombed

Cockburn, A. (2007). In Iraq, anyone can make a bomb. *LA Times*. Retrieved from http://www.latimes.com/news/la-oe-cockburn16feb16-story.html

Cohen, J. (1992). A power primer. *Psychological bulletin, 112*(1), 155.

Crawford, K. J. (2009). *IED Defeat Gated Training Strategy: A Holistic Approach to Preparing Units and Soldiers for Combat*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a592683.pdf

Defense, D. o. (2012). Department of Defense Design Criteria Standard: Human Engineering: MIL-STD-1472G. Washington D.C.: Departmet of Defense.

Defense, N. (2008). Marines MRAP Impedes Operations. *National Defense*(January).

Department of Defense Directive 2000.19E. (2006). Washington D.C.: Department of Defesne Retrieved from https://www.jieddo.mil/content/docs/20060214_DoD_Directive_JIEDDO.pdf

Diez, D. M., Barr, C. D., & Cetinkaya-Rundel, M. (2015). *Open-Intro statistics: Third Edtion*: CreateSpace independent publishing platform.

Dotterway, K. A. (1992). *Systematic analysis of complex dynamic systems: the case of the USS Vincennes*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a260260.pdf

Eisler, D. (2012). Counter-IED strategy in modern war. *Military Review, 92*(1), 9.

Ellis, R. F., Rogers, R. D., & Cochran, B. M. (2007). *Joint Improvised Explosive Device Defeat Organization (JIEDDO): Tactical Successes Mired in Organizational Chaos; Roadblock in the Counter-IED Fight*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a473109.pdf

FM 3-21.8 The Infantry Rifle Platoon and Squad. (2007). Washington D.C.: Headquarters, Department of the Army.

FM 3-21.10 The Infantry Rifle Company. (2006). Washinton D.C.: Government Publishing Office.

FM 5-31 Boobytraps. (1965). Washinton D.C.: Department of the Army.

Gallagher, S. (2015, August 26, 2015). Meet the Humvee's Replacement: Oshkosh's L-ATV. *ARS Technica*. Retrieved from http://arstechnica.com/tech-policy/2015/08/meet-the-humvees-replacement-oshkoshs-l-atv/

Garaux, J. M. (2009). *The United States Improvised Explosive Device Fight: Technical Shortcomings and the Value of Strategy*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a509727.pdf

Good, M. T. (2010). *The lED: Tactical Solutions for a Tactical Problem*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a602995.pdf

Government, A. O. (2009). *WARFIGHTER SUPPORT Actions Needed to Improve Visibility and Coordination of DOD's Counter-Improvised ExplosiveDevice Efforts*. Retrieved from Washington D.C: http://www.dtic.mil/get-tr-doc/pdf?AD=ADA508708

Hakola, M. B. (2004). *An exploratory analysis of convoy protection using agent-based simulation.* DTIC Document. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a424962.pdf

iCasualties.org. (2015). Operation Enduring Freediom Casulties. Retrieved from http://icasualties.org/OEF/Fatalities.aspx

JIEDDO. (2008). Joint Improvised Explosive Device Defeat Organization annual report FY 2008: Washington DC: JIEDDO.

JIEDDO. (2009). *Annual Report FY 2009*. Washington D.C: JIEDDO Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a529285.pdf

JIEDDO. (2011). *JIEDDO Annual Report 2010*. Washington D.C.: JIEDDO Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a549447.pdf.

JIEDDO. (2012). *Strategic Plan 2012-2016*. Washington, D.C.: JIEDDO Retrieved from https://www.jieddo.mil/content/docs/20120116_C-IEDStrategicPlan_ExSum_Final-Web.pdf.

Jones, I. (2004). *Malice Aforethought: The History of Booby Traps from World War One to Vietnam*: Greenhill Books/Lionel Leventhal.

JP 3-15.1: Counter-Improvised Explosive Device Operations. (2012). Retrieved from https://info.publicintelligence.net/JCS-CIED.pdf

Lockheed, M. (2011, 15 MAR 15). Lockheed Martin Delivers 2,000th Symphony Improvised Explosive Device Jamming System. Retrieved from http://www.lockheedmartin.com/us/news/press-releases/2011/may/symphony.html

MAK, V. (2015a). ECOSim. Retrieved from http://www.mak.com/products/humans/eco-sim.html

MAK, V. (2015b). VR-Forces Capabilities. In MAK (Ed.). Cambridge, MA: VT MAK.

Martin, B., Manacapilli, T., Crowley, J. C., Adams, J., Shanley, M. G., Steinberg, P., & Stebbins, D. (2013). *Assessment of Joint Improvised Explosive Device Defeat Organization (JIEDDO) Training Activity*. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a590699.pdf

Morgan, J. M. (2012). *US Army Land Navigation in the 21st Century*. Retrieved from http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA563009

PROTOCOL ON PROHIBITIONS OR RESTRICTIONS ON THE USE OF MINES, BOOBY-TRAPS AND OTHER DEVICES(PROTOCOL II), (1980).

NATO. (2012). *AJP-3.15 (B) Allied Joint Doctrine for Countering - Improvised Explosive Devices*: North Atlantic Treaty Organization.

Obama, B. (2013). *Countering Improvised Explosive Devices*. Retrieved from https://www.whitehouse.gov/sites/default/files/docs/cied_1.pdf

Parascadola, r. E., Heidi; Hutchinson Bill. (2013, April 16, 2013). Boston Marathon bomb devices were pressure cookers filled with nails, ball bearings: report. *New York Daily News*. Retrieved from http://www.nydailynews.com/news/national/boston-marathon-bomb-devices-made-pressure-cookers-filled-nails-ball-bearings-report-article-1.1318278

Partlow, J. (2010). Zabul province seeks U.S. troops, but is caught in Afghan numbers game. *Washington Post*. Retrieved from http://www.washingtonpost.com/wp-dyn/content/article/2010/03/08/AR2010030804916.html

Perlo-Freeman, S., Fleurant, A., Wezeman, P. D., & Wezeman, S. T. (2015). Trends in world military expenditure, 2014. Retrieved from http://books.sipri.org/files/FS/SIPRIFS1504.pdf

Pettitt, R. A., Redden, E. S., Turner, D. D., & Carstens, C. B. (2009). *Recognition of Combatants-Improvised Explosive Devices (ROC-IED) Training Effectiveness Evaluation*. Retrieved from http://www.arl.army.mil/arlreports/2009/ARL-TR-4744.pdf

Proctor, M., & Paulo, G. (1996). Modeling in support of operational testing. *Mathematical and computer modelling, 23*(1), 9-14.

Sadowski, R. W. (2008). *Joint Improvised Explosive Device Defeat Organization: Anomaly or Future Roadmap*. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA479728

Schatz, S. D.-L., Rhianon; Colombo, Gian; Taylor, Andrea; Vogel-Walcutt, Jennifer. (2011). *Advanced Pereptual Skills: Improving Thier Training, Evaluation, and Operational Effectiveness*. Paper presented at the International Conference on Natualistic Decision Making (NDM 2011), Orlando, FL USA.

Sisk, R. (2013, 15 Mar 15). U.S. Troops Faced Pressure Cooker IEDs in Iraq and Afghanistan. *Defense Tech.* Retrieved from http://defensetech.org/2013/04/17/u-s-troops-faced-pressure-cooker-ieds-in-iraq-and-afghanistan/

Solis, W. M. (2009). *Warfighter Support: Challenges Confronting DoD's Ability to Coordinate and Oversee Its Counter-Improvised Explosive Devices Efforts: Congressional Testimony*. Retrieved from http://www.gao.gov/assets/130/123676.pdf

Solis, W. M., Russell, C. B., Coleman, G., La Due Lake, R., McAllister, L., To, T. T., . . . Strong, J. (2010). *Warfighter Support: Actions Needed to Improve the Joint Improvised Explosive Device Defeat Organization's System of Internal Control*. Retrieved from http://www.gao.gov/assets/310/306400.pdf

Ucko, D. (2009). The new counterinsurgency era. *Transforming the US Military for Modern Wars, Washington, DC*.

Vanden Brook, T. (2011). Foot patrols in Afghanistan boost IED detection. *USA Today*. Retrieved from http://usatoday30.usatoday.com/news/military/2011-05-23-military-IED-Afghanistan_n.htm

Vanden Brook, T. (2015, August 26, 2015). Safer Truck to Replace Humvee. *USA Today.* Retrieved from http://www.usatoday.com/story/news/nation/2015/08/26/humvee-mrap-jltv/32431165/

Vane, M. A., & Quantock, D. E. (2011). *Countering the Improvised*. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA541350

Weisgerber, M. (2013, 15 MAR 15). JIEDDO to Shrink, but Expand Mission. *Defense News.* Retrieved from http://archive.defensenews.com/article/20131206/DEFREG02/312060014/JIEDDO-Shrink-Expand-Mission

Wilson, C. (2007). *Improvised explosive devices (IEDs) in Iraq and Afghanistan: effects and countermeasures*. DTIC Document Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a475029.pdf.

Zoroya, G. (2013, December 19, 2013). How the IED changed the U.S. military. *USA Today*. Retrieved from http://www.usatoday.com/story/news/nation/2013/12/18/ied-10-years-blast-wounds-amputations/3803017/