University of Southern Queensland
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VEHICLE UNDERCARRIAGE SCANNING SYSTEM

A dissertation submitted by

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Abstract

September 11th terrorist attack had caught the world in surprise. Establishment around the world like Airport, Military camp, Government building, Hotel, Hospital, Shopping mall, stadium, Oil and Gas facilities etc, uses undercarriage vehicle scanning system to deploy active, stringent security check on the underside of vehicle, looking out for contraband items at sensitive location where threats are conspicuous. Contraband items in this project are known as Improvised Explosive Device (IEDs) or fire-arms. These were handled by terrorist and could cause substantive amount of damages. Current technology or method used to deter contraband items is not manpower, safety, time and competence favor. In additional, mobility of such checkpoint is a problem.

Heavy manpower is deployed for a routine undercarriage security check. They worked under inconducive environment and were using down to earth gadget. Garget is made up of trolley like flat cart with reflective mirror mounted on the top of the cart. They are push under the vehicle carriage for inspection. Officers make use of mirror reflection to detect for contraband items. Officers were not technically competence enough and vigilance reduces after times.

Similar conceptual undercarriage vehicle scanning project are available in the market. However, designs are not duly customized to security agencies requirement. In view of that, this project wills emphasis on a customised integrated system, which consists of scanning platform and strategically mounted cameras to allow maximum view of the undercarriage.

Undercarriage images are captured in colored and displayed on monitor where preliminary assessment of dubious items before it proceed on. Images are automatically saved as .jpeg format in the hard disk to facilitate future investigation or comparison when the same vehicle returns on second instances.

Optimizing the most productive use of available resources, additional cameras are used to control independency and allow methodical search. System possesses silent alert features to the main control room upon activation of contingency dash through system. Contingency dash through stoppage on vehicles in seconds and avoid disaster attack from happening. In

addition, coordinated vehicle traffic flows without any human interference, through diligent use of sensor.

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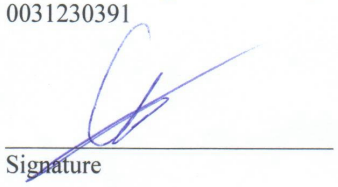

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General Statement

Undercarriage Vehicle Scanning System comprises of cameras and a drive platform. Cameras are installed to capture vehicle undercarriage images, while the platform would raise the vehicle off the ground, providing greater camera viewing area. When a vehicle drive over the platform, the cameras installed beneath captured the undercarriage image and sent to a terminal for viewing. Officer on terminal duty would check the image visually for dubious items, before allowing the vehicle to proceed on.

Undercarriage Vehicle Scanning System is easy to operate and required minimal or no job training. It is both effective and efficient; the system enables officer to conduct quick and thorough vehicles undercarriage inspections prior entry. Efficient use of cameras means manpower saving from physical checking of vehicle undercarriage. Camera detection is one hundred percentage more effective than human labour. Image accuracy does not deteriorate with time and fatigue as compared with human. Therefore, efficiency extends to 24hours a day.

Nevertheless, undercarriage vehicle scanning systems were not customized design to security agencies requirement. Agencies adopt plug and play mentallogy- “change of method to compromise hardware lapses.” Manpower were not effectively deployed and maxmise from the available resources. This further escalated into terrorist success intrusion because of system inefficiency.

On afternote, the current available system was unable to generate necessary data needed for analysis. For instances, images of vehicle suspension were not possible. This is a phenomena of cameras blind spots. There is no defence system against dash through vehicle carrying destructive substances. These lapses had adverse consequences and are overcome by additional manpower. Concurrently, dashes through situations are resolved temporary by deploying current available equipment such as cat claw to burst vehicle tires manually.

In view of the constraint, it is vision to improve after market available undercarriage vehicle scanning system into mobility, emphasizing on the platform design and availability of data from cameras for reviewing. Vehicle undercarriage system would integrate with access

control system to stop vehicle that attempts to break through the checkpoint. In doing that, the system pledge to achieve maximum automation, thus reducing manpower. The system is able to provide sufficient time for the users to examine the vehicles without any holding up traffic flow through diligent use of sensor and structured guidance. The system is also equipped with contingency dash through capability. It could be either computer or manually activated to stop attempted dash thorough vehicles yet considering false alarm.

Terminal Station completes with a processor and LCD screen, allows monitoring, displaying, recording, and managing the video images easily. A complete undercarriage image displays on the screen, allows the users to conduct a rapid and detailed examination of the vehicle undercarriage. Captured images are stored as .jpeg format in a computer hard disk for future reference and investigation if necessary.

Automatic licence plate recognition software can be incorporated to obtain the vehicle number plate and the image of the driver (optional feature - additional cameras required)

"We, the terrorist need to be lucky once, you (security agent) need to be lucky always" (Internal Security Department, Singapore security symposium, 2004). Err on the side of human mistake could not be tolerated, instead could improve to achieve same or better quality from the system intelligence.

1.0 Introduction

Terrorism had been a problem for travelers since 1970s. Their threats of hijacking and bombing act as a subversive against militant organization. It was not until September 11th 2001 that terrorist threats had been taken more cautiously. The unfamiliar topic of al-Qaida had dominated within the conversion of many. Terrorist's threats are thereafter known to be extensive to many ignorant lives and had forced security checks at controlled area to be tighter.

Ever since 911 incidents, President Bush said in an address to Congress on September 20, 2001, "Our war on terror begins with Al-Qaida, but it does not end there. It will not end until every terrorist group of global reach has been found, stopped, and defeated." In the wake of September 11 2001, information on the hijackers' activities was available through databases at the federal, state, and local government levels as well as within the private sector. So we must build a system that brings together threat information from a variety of sources and transmits it to relevant law-enforcement and public-safety officials (Tom Ridge, Director of Office of Haomeland Security.

It has been widely noted that both "the American intelligence community" (approximately 15 different agencies) and the various military and civilian agencies in charge of fighting terrorism (at least 40 of them) utterly failed to anticipate, prevent or minimize the severity of the devastating terrorist attacks on civilian and military targets in New York City and Washington, D.C., on 11 September 2001. Despite the facts that every year the United States spends approximately $30 billion on intelligence gathering, analysis and another $11 billion on counter-terrorism.

Terrorist choose significant target, which are more destructive and could cause massive casualties and moral impact on the citizens and country. Therefore, it is important to emphasize on the first line of defense; the barriers, fence and wall. Security means preparedness and have always emphasized redundancy and backups in our systems. Security also means confidence. People need to feel confident that financial information presents a sufficiently clear picture of the company and that the markets are safe from manipulation. (Richard Ketchum, President, the Nasdaq Stock Market Inc.

2.0 Literature Review

2.1 Contraband items

Contraband items refer to items or products that are forbidden. It could be in any form (solid, liquid) that the authorized security agency had banned or control. In general it specify from unknown food contents to controlled drugs and explosive. However, in our context of research, contraband items generally extend to any gadget or items, which could bring threat to human safety, such as guns, knives and Improvised Explosive Devices (IEDs).

Generally, public at large do not carry these items accidentally. Neither would they associate themselves with these items inappropriately. For instances, it is by large accepted that all household will used knives in kitchen or during meal cooking hours. Having saying that, they are used safely and appropriately in preparation of meals. However, carrying hidden knives strategically into sensitive events or function served their suspicious and would indeed not practice by majority. Terrorists or person with sabotaging plans would chance the risks against being caught. Advent, these contraband items are used wrongly, bodily hurt the innocents. If contraband items are left uncontrolled, they become increasingly rampant, achieving towards terrorists mission.

The uses of bombs on their targets are on the rise. Bombers camouflaged these bombs via any medium they can resource and transport them to the designated place in waiting for the right time to ignite, causing mass casualties. The core responsibilities of police intervene to protect lives and properties. We will elaborate more on IEDs and understanding on their destructive levels.

2.2 Introduction of Bombs

A typical bomb contains explosive material, which burns or decomposes very quickly. It would activate when triggered by heat or shock before undergoing a rapid chemical reaction with combustion or a decomposition reaction, producing lot of heat and gas in a short amount of time.

Explosives are classified as either low or high according to the detonating velocity or speed at which the decompose takes place and other pertinent characteristics such as their shattering effect. Low explosives are said to burn or deflagrate rather than to detonate or explode. The burning produces gas kept in confined will cause an explosion. Most low explosives are made up of mechanical mixtures or a low mechanical blending of explosive. In a deflagration, the chemical reaction moves rapidly through the explosive material and releases heat or flames vigorously.

In contra, high explosive does not require confinement to cause high explosion. It is initiated by a shock wave of considerable force. High explosive comes with detonator or blasting cap.

There are three types of explosions accompanied by shock, light, heat and loud noise. They are atomic, mechanical (characterised by a gradual build-up of pressure in a container until it overcomes the structural resistance and exploded like a pipe bomb), and chemical (the rapid conversion of a solid or liquid explosive compound into gasses having much greater volume than the origin substances).

Before explosion takes place, there are three rates of combustion namely ordinary combustion, rapid combustion, and lastly instantaneous combustion. (There is actually a time interval where combustion passes from one particle of explosive compound to the next.) When an explosive is detonated, chemical explosive material is instantaneously converted from solid into a rapidly expanding mass of gasses. The velocity of instantaneous combustion has been measured for most explosives and is referred to as the detonation velocity of the explosive. Detonation velocities of high explosives range from approximately 3,300 feet per second fps to over 29,900 fps.

In a detonation, the chemical reaction moves through the high explosive material at a velocity greater than that of sound through the same material. The explosives velocities and configuration have a direct relationship to the amount of destruction they can perform. Low explosives have pushing or heaving power and high explosives have shattering power (Brisance).

Explosive blast pressure is the most powerful of all explosive effects. When explosion occurs, the temperature raises from 3000 to 7000 Fahrenheit expanding the gases at a period of approximately 1/10,000 of a second. These heated gases posses' pressures of about 700 tons per square inch on the atmosphere and velocities of up to 13,000 miles per hour or 29,900 fps. The expanding gas rolls out from the point of detonation like a ripple in the water is known as the blast pressure wave. This wave has two distinct phases positive and negative. Positive blast pressure wave moves outward from the point of detonation and destroy everything in its path. It lasts a relatively short period of time. Negative blast pressure is descriptively known as the suction phase. It is three times longer in duration but of less intensity than the positive phase. It is formed as the out rushing air is compressed and forms a vacuum at the point of detonation. The vacuum causes the displaced air to reverse its movements and return to the point of detonation.

Incendiary Thermal Effect can vary greatly from one explosive to another. In general, low explosives will produce longer incendiary thermal effects than will high explosives. A high explosive will produce higher temperatures but for a shorter time. The effect is seen usually as a bright flash or fireball at the moment of detonation. The low explosive fireball is more likely to cause a secondary fire than a high explosive detonation.

Ground and Water shock; occur when an explosive is initiated while buried in the earth or submerged under water. Both earth and water are less compressible than air and tend to propagate a shock wave further and with more force than air. Therefore, structural damage may be substantially greater under those circumstances where earth and water are involved. Water cannot be compressed at all and, therefore, will transmit energy much faster and farther than any other medium (tamping).

Overpressure; types of overpressure include Incident Overpressure: a result of the explosive pressure wave itself and Reflective Overpressure; a result of the explosive pressure wave hitting a surface and rebounding, increasing the overpressure value. The effect of overpressure on the human body varies depending on; distance from explosion, nature of surroundings, and the age and physical condition of the individual.

2.2.1 Ingredients of Bomb

In chemical reaction, the chemical compounds break down to form various gases. The reactant known as the original chemical reaction has a lot of energy stored as chemical bonds between different atoms. When the compound molecules breaks apart, the resulting gases may use some of this energy to form new bonds, but not all of it. Most of the left over energy takes the form of extreme heat. The concentrated gases are under very high pressure, so they expand rapidly. The heat speeds up the individual gas particles, boosting the pressure even higher. In a high explosive, the gas pressure is strong enough to destroy structure, injure and kill people. If the gas expands faster than the speed of sound, it generates a powerful shock wave. The pressure can also push pieces of solid material.

2.3 Disguise Bombs

2.3.1 Package IED

The enemy in Iraq had used IEDs consisting of mortar and artillery projectiles as the package explosive device. The characterizes use of these package IEDs as follow:

- Thrown from overpasses.
- Thrown in front of approaching vehicles from roadside.
- Usually thrown by males—who are not always adults.
- Emplaced in potholes (covered with dirt).
- Emplaced along MSRs and alternate supply routes (targeting vehicles).
- Employed along unimproved roads (targeting patrols).
- Employed with 120-mm and larger artillery or mortar projectiles.
- Found alone or in groups.
- IEDs behind which are placed cinder blocks or piles of sand to direct blast into the kill zone.
- Command detonated—either by wire or remote device.
- Time-delay triggered IEDs. IEDs that can be detonated by cordless phone from a car (allows for mobile firing platform and prevents tracing or triangulation).

The design and placement of a disguise bomb is up to the imagination of a bomber. The rule of thumb, if it should not to be there in the first place, we shall take it a suspicious. Package bomb can be in the broad categories of disquette bombs, plastic explosive or solidox bomb or even simply pipe bombs

2.3.2 Vehicle Borne IEDs (VBIEDs)

VBIEDs use the vehicles as a package or disguise for the explosives. These IEDs come in all shapes, colors, and sizes, which vary by the type of vehicles available, from small sedans to large cargo trucks, which are more destructive. Previously, there have even been instances of generators, donkey drawn carts, and ambulances attempt to attack on Coalition Forces and the New Iraqi Government.

The device works within the same concept as the package types IEDs and possess the common characteristics or indictor as other IEDs. From figure 1, it shows the amount of explosive with categories of vehicles. VBIEDs have increasingly used larger amounts of explosives and the explosive charge, which includes mortar rounds, rocket motors, rocket warhead, PE4 explosive and artillery rounds has ranged from 100lbs to well over 1000 pounds. Figure 1 shows the amount of explosive that can be contained in a vehicle.

BATF Explosive Standards

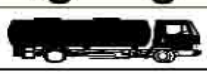
ATF	Vehicle Description	Maximum Explosives Capacity	Lethal Air Blast Range	Minimum Evacuation Distance	Falling Glass Hazard
	Compact Sedan	500 pounds 227 Kilos (In Trunk)	100 Feet 30 Meters	1,500 Feet 457 Meters	1,250 Feet 381 Meters
	Full Size Sedan	1,000 Pounds 455 Kilos (In Trunk)	125 Feet 38 Meters	1,750 Feet 534 Meters	1,750 Feet 534 Meters
	Passenger Van or Cargo Van	4,000 Pounds 1,818 Kilos	200 Feet 61 Meters	2,750 Feet 838 Meters	2,750 Feet 838 Meters
	Small Box Van (14 Ft. box)	10,000 Pounds 4,545 Kilos	300 Feet 91 Meters	3,750 Feet 1,143 Meters	3,750 Feet 1,143 Meters
	Box Van or Water/Fuel Truck	30,000 Pounds 13,636 Kilos	450 Feet 137 Meters	6,500 Feet 1,982 Meters	6,500 Feet 1,982 Meters
	Semi-Trailer	60,000 Pounds 27,273 Kilos	600 Feet 183 Meters	7,000 Feet 2,134 Meters	7,000 Feet 2,134 Meters

Figure 1: Chart on types of vehicle against capacity of explosive

2.3.3 Suicide IEDs

Suicide IEDs are carried by suicider with large amount of explosives and fragmentary effect used to cause much casualties and death in soldiers and civilians. Deadly force is normally the only response option in protecting their loves and others.

Fragmentation explosive can be contained in a vest, belt, or clothing that is specifically modified to carry these IEDs concealed. Vehicle-borne suicide bombs employ the same methods and characteristics of other package or vehicle bombs using a command detonation firing system.

IEDs can be made from any types of material and initiator of different sizes, functioning methods, container and most important is the delivery methods. As the name improvised explains, it is a "homemade" device, that is designed to cause injury and even death by using a combination of toxic chemical, biological toxin, explosive and radiological materials. IEDs can utilize commercial or military explosives, homemade explosives or military ordnance and ordnance components. They are unique in nature because the IED builder had to improvise with the materials at hand. Raw IEDs component in nature are not destructive but could be designed to defeat a specific target or type of target, they generally become more difficult to detect and protect against as they become more sophisticated.

Although IEDs varies in shape and the standard sets of component are

- Fuze or initiation system
- Explosive fill
- Detonator
- Power supply for detonator
- Container

2.3.4 Dirty Bombs

A "dirty bomb" is a conventional explosive such as dynamite packaged with radioactive material that scatters when the dirty bomb goes off. A dirty bomb kills or injures through the

initial blast of the conventional explosive and by airborne radiation and contamination, hence the term dirty bomb. Such dirty bombs could be miniature devices or as big as a truck bomb. The destructive power of a dirty bomb would really depend on the size of the conventional bomb, and the volume and nature of the nuclear material. A dirty bomb would be messy but effective for many reasons. A dirty bomb is the type of weapon you would build if you could not construct a conventional nuclear device.

A dirty bomb will most likely contain more than a teaspoon of cesium chloride. It is best to consider real-life experience than to speculate about the possible effects from a dirty bomb explosion.

Consider the small city of Goiania, Brazil: A scrap-yard worker pries open a lead canister that was scavenged from an abandoned cancer treatment center and dumped at the yard five days earlier. Inside the canister the man is delighted to find a sparkling blue powder; he has no idea the powder is radioactive cesium. All told more than 200 people are exposed to the cesium. A radiation disaster second only to Chernobyl in size and scope causes the deaths of four people, including a six-year-old girl who rubbed the powder over her body and hair so that she glowed. The radioactivity contaminates soil, businesses, and homes, 85 of which are leveled during the cleanup process.
90 grams of cesium chloride is enough to cause this tragedy?

Unprotected radioactive substances uses as dirty bomb have been found in Russia and in the United States. Consider the theft of large quantities of cesium chloride from a Greensboro, North Carolina Hospital in 1998. Nineteen small tubes of cesium go missing from a locked safe in Moses Cone Memorial Hospital. Each only three-quarters of an inch long by one-eighth of an inch wide, the tubes were being stored for use in the treatment of cervical cancer. Though local, state, and federal officials scour the city using sophisticated radiation-sensing equipment, the cesium is never recovered. Authorities believe whoever stole the cesium tubes may have been trained to handle the material, since unprotected contact with the tubes could have caused serious injury or even death. More cesium was stolen from Moses Cone Memorial Hospital, than was dispersed in Goiania Brazil.

The extent of local contamination would depend on a number of factors, including the size of

the explosive, the amount and type of radioactive material used, and weather conditions. Prompt detect ability of the kind of radioactive material employed would greatly assist local authorities in advising the community on protective measures, such as quickly leaving the immediate area, or going inside until being further advised. Subsequent decontamination of the affected area could involve considerable time and expense. Most areas of the United States do not contain adequate detection equipment to alert residents or law enforcement of a dirty bomb threat. A second type of RDD might involve a powerful radioactive source hidden in a public place, such as a trash receptacle in a busy train or subway station, where people passing close to the source might get a significant dose of radiation. Dirty Bomb detection equipment used by community members would greatly improve the chance of finding this kind of RDD. [21]

2.4 Bombs Detection

2.4.1 Bomb Sniffer

Bomb sniffer is a hand-carried gadget that, like a trained police dog, could sniff out the vanishing faint odors of drugs and bombs at airports, border crossings, military installations, and schools. The portable device is a miniaturized version of an explosives-detecting walk-through portal. The portal, which blows a puff of air over an airline passenger and checks for minute levels of explosives in the air flow.

2.4.2 Vapour Detector

Sniffers is a vapor detectors and particle detectors, generally known as sniffers to identify explosives by their particulate or gaseous elements. When properly used, sniffers can assist in the limited detection of a narrow range of explosive compositions, but negative results always require other methods of screening. Like the other technologies that will be discussed below, sniffers should only be used as one part of a layered bomb detection strategy. They should never be used as a standalone system.

A vapor detector can identify volatile explosive compounds that have a high vapor pressure, such as nitroglycerin found in older dynamite made with a formula that has since changed. The device, which costs between $15,000 and $50,000, collects vapor samples through a vacuum as it is run over a package, then analyzes them for vapors generated by certain explosives. The results take only a few seconds to complete. However, vapor detectors will miss explosives with a low vapor pressure, such as plastic explosives, PETN, or black powder. Before purchasing a vapor detector, the security manager should have the system thoroughly tested by the local bomb squad to see which explosive substances it is capable of detecting. In addition, the test should be conducted under realistic circumstances. For example, since a criminal may go through great pains to seal explosives to make them difficult to detect, the test team should seal the explosives tightly before putting it in the package or briefcase that will be tested. Many labs simply test devices by bringing them in direct, or at least close, contact with the explosive compound, something that almost never happens in the real world.

2.4.3 Chemical Preconcentrator

Improvements in the underlying chemical preconcentrator technology are enabling ever-smaller sniffing tools. Miniaturization of the preconcentrator has allowed them to develop smaller detection tools that are portable, cheap, sensitive, and fast.

The preconcentrator works by drawing in a large volume of air, collecting heavy organic compounds from the air stream onto a filter, then vaporizing these organics into a smaller parcel of air that is delivered to a commercial explosives detector. By drawing greater volumes of air past the filter using a clever design trick, the researchers have been able to shrink the preconcentrator's air intake and valves ranging from a nine-inch diameter to a one-inch diameter, enabling increasingly smaller sniffers. The preconcentrator heats up the swipe and draws the vaporized compounds into the sniffer for detection. In all, the swipe sniffer is about a size of a large lunch box. Now, rather than taking crime-scene swipes of chemical particulates back to a crime lab for analysis, forensics investigators can place the swipes into the portable sniffer for analysis on the spot

The device expands crime-scene investigators' capabilities to detect residues of both explosives and narcotics. Referring to Figure 2, the portable sniffer is much more sensitive, capable of detecting less than a nanogram of explosives residue on the swipe. For comparison, the fingerprint of a person who had handled a bomb or a suitcase with explosives in it would likely contain 100,000 times more residue. With the new device, many more chemical analyses can be performed by forensics teams at the crime scene, which may improve the quality of evidence collected.

Figure 2: Crime scene sniffer

The second type of new instrument is preconcentrator fitted onto the front of a commercial sniffer, which can detect nanograms of explosives from several cubic feet of air drawn from the seams of a car trunk or school locker. The device might be useful for explosives detection at border crossings or during traffic stops.

Unlike a dog, the sniffer never gets tired, you don't have to feed it, and you can switch it off when you don't need. Although a dog's nose is somewhat more sensitive than the sniffing device, a trained dog can't work reliably for more than 30 or 40 minutes without a rest. Dogs are very good at smelling things; so electronic sniffers may never be as good as a dog's nose. With a preconcentrator it can detect incredibly small traces of chemicals well enough without the logistics problems associated with dogs. So far with promising results the sniffer gave promising result with high reliability. Sensors could be mass-produced and, therefore, cost-effective. In the future, they could replace dogs as the primary detectors of explosives. Dogs can not be strapped to packages, ventilation systems or airport walls. Dogs are complex animals that require training. They need naps, they need to eat, and they can only be at one place at one time. You can't train a dog and then multiply it by a million and have copies communicating with each other over a building network. You can do this with silicon and signal processing technology.

Using a mass spectrometer, rather than an ion mobility spectrometer, as the sniffer detector would enable a next-generation airport portal to reliably detect explosives, narcotics, and chemical and biological warfare agents with one sniff.

At the heart of the device is a prism of extremely pure, highly polished silica (SiO2) called an optical resonator. Although researchers have been studying these prisms for about four years, this is the first time they have been used to sniff out chemicals.
The detector works by exploiting a unique property of optical resonators called cavity ring-down, or CRD. A pulse of light from a laser is fed into the resonator, where it becomes trapped by the highly reflective walls of the prism, much in the same way that light is contained by the sides of a fiber-optic cable. Under normal conditions the light pulse spins around and around in this virtual cavity for a total distance of about a mile. After running this many laps in the 7mm prism, the light pulse eventually runs out of energy and can no longer be detected. The time taken for the pulse to disappear is called "ring-down time."

If, however, there is a molecule of a particular substance, like a chemical known to be in explosives, in contact with the super-smooth walls of the optical resonator, it absorbs some of the light pulse, causing the ring-down time to get shorter. By measuring this change in the ring down-time, it is able to detect the presence of the chemical. The capture of explosive particles requires special air handling.
Explosives have very low vapor pressures, and don't give off a lot of molecules at room temperature, so what a shake up of a few particles, heat them up, get a hold of a couple of particles, and run their vapor by the sensors. An air conditioning system used at the front entrance of a building could help dislodge the particles and drive them towards an array of distributed sensors. The technology could be used anywhere you want to know if there's someone moving around with explosives, like in countries where there are constant acts of terrorism.

2.4.4 Particle Detector

The other type of sniffer is a particle detector, which looks for trace amounts of chemical compounds that may be found in some explosive devices. These devices analyze the

chemical signatures of the substances present on a package. The technology works on the premise that if a person has been handling explosives, their hands will be contaminated with residue, which will then be transferred to the package. Samples are collected either through a vacuum hose or with swipe pads, gloves, and cards. The sample is placed into the particle detector, which heats up the substance and displays the results on the system's small monitor.

These instruments, which cost $25,000 and up, are ideally suited for detection of postblast explosive residues, and have been helpful in investigations like the World Trade Center and the Alfred P. Murrah Federal Building bombings. Particle detectors have also been used with marginal success to sample rooms where suspected terrorists have developed an explosive device. Like the vapor detector, the particle detector should never be used, as the only tool available to the security professional and all negative results should always be verified with other screening methods, such as x-ray.

These instruments are best at identifying rarely used explosive compounds such as RDX, PETN, HMX, NG, TNT, DNT, and some bulk nitrate explosives. Most bombings in the United States consist of pipe bombs filled with smokeless or black powder, which particle detectors are currently incapable of identifying. In rare circumstances, however, the particle detector may detect nitrates present in high quantities.

Well-sealed explosives may not be identified by the particle detector. Also, because the device requires operators to vacuum or swipe packages, the suspect items are subject to handling forces that may cause them to explode. For example, to collect valid samples with the vacuum model, the nozzle must have good contact with the surface of the package. Vacuum systems that do not make contact with the surface are ineffective.

Although unlikely, the vacuum hoses may cause a sufficient amount of static electricity discharge to initiate a bomb's firing components or explosive compounds. To use a particle detector with a vacuum collection system safely, the hose should be shielded, insulated, and grounded. Operators should use approved static discharge devices, which can be acquired through industrial safety equipment suppliers. They should be grounded at all times while performing screening. Operators should wear cotton clothing and never wool, nylon, or other

static-producing garb. Operators should never remove, add, or adjust clothing during a test since this could cause static.

2.4.5 X-Ray

The x-ray machine is the safest and most effective tool for screening mail, briefcases, purses, and other incoming containers for explosive devices. Used in mailrooms and as part of access control systems, these devices can cost anywhere from $2,500 to more than $150,000. The price depends on three factors: the type of x-ray technology, the style, and the power. In addition, security managers may need to choose among several standard features and options, although the choice may not affect price.

There are three types of x-ray technologies are on the market today, including a straight x-ray such as that used in a dentist's office to examine teeth; dual energy; and backscatter, a relatively new technology.
For most corporate environments, x-rays come in 60, 90, or 140 kilovolts of penetration power. A company should use an x-ray with a minimum of 90 kilovolts, which can penetrate 1/4-inch of steel or a full U.S. Postal Service mail tray. In general, machines of 140 kilovolts are not needed in mail rooms, but they may be appropriate in loading docks where packages are bigger. A 60-kilovolt machine will only see through half a mail tray, requiring mail room personnel to frequently empty out trays or bags--an inconvenience that may encourage them to stop using the x-ray. The security manager must ensure that an uninterruptible power supply is used on the x-ray system to help prevent picture loss during power outages. At a minimum, a surge protector should be installed to prevent damage from electrical spikes.

Various features may be added to either a cabinet or conveyor style x-ray. The security manager should consider how the machine will be used before determining which features are necessary. For example, machines come with either movable or attached keyboards--which are used to operate the x-ray. Movable keyboards offer the most flexibility, especially if the company plans to move the machine between duties.

In addition, the security manager should ensure that the straight x-ray has a color enhancement capability, which is not the same as organic and inorganic detection. A color

enhancement feature, which should not add any additional cost to the system that allows an operator to see color with the push of a button so that he or she can further evaluate a suspicious image. The colors relate to the density of an object, not its actual color. In one system, for example, dark-colored or dense items are displayed as a deep red, while lighter objects are displayed in faint orange. Object of medium density shows as green.

Although black and white always gives the best contrast and should be used by operators in most cases, color enhancement can help an operator focus on certain images once a suspicious object has been identified. For example, let's say a pistol is sitting in a briefcase next to an umbrella. Because the two objects are touching, they may appear as one object on a black-and-white screen, making it difficult for the operator to positively identify the weapon. However, because parts of object looks like the barrel of a gun, the operator switches to color enhancement. With this feature, the dense gun shows up as a deep red, while the umbrella may come up green--separating the items as two distinct objects.

Many xrays come equipped with standard or optional front and rear extensions. This is especially true of the larger types, such as are seen in airports. These extensions can add several hundred to several thousand dollars to the price. To save money, some companies build their own extensions. One technique used in mailroom applications is to attach a heavy wooden door (or other flat items that might be available at the company) on stands that are perpendicular to the machine's inspection tunnel. Although not as aesthetically pleasing as a manufactured extension, this technique gives the operator a substantial amount of room in which to work.

Manufacturers also offer "edge trace" and "warning" options. Neither feature should increase the cost of the system. The edge trace feature defines the edges of different objects to help the operator better distinguish suspicious items. The warning features will red flag dense objects that cannot be penetrated with the x-ray. In one system, for example, those objects will flash in red on the monitor. Warning options are best left off an x-ray machine, however. Operators may become complacent and start relying too heavily on a warning system that is far from perfect.

2.4.6 Conveyor Belt

An x-ray machine with a conveyor belt is the most popular and most effective. This machine has two open ends and a conveyor belt that moves through the device at about forty-five feet per minute. One or two Super VGA monitors (depending on which x-ray technology is used) allow operators to view the contents of packages as they move through the x-ray beam.

Although expensive (these systems can run $15,000 to $75,000), a conveyor belt x-ray is highly effective for both mail room and access control operations because employees will use the easy-to-operate machines.

The security manager should look closely at the machine's inspection tunnel to ensure that it will be able to fit large packages. In general, an inspection tunnel should measure at least seventeen inches high if it is being used in a mail room. X-ray machines at loading docks should have an inspection tunnel that is at least twenty inches high to handle large packages. The widths of x-ray machines are fairly standard, running about sixteen and twenty inches.

The security manager may also consider buying a lightweight portable x-ray device, which can cost $2,500 to $40,000. These devices are for highly trained search teams or executive protection personnel. Portable x-ray devices offer one of the best ways to examine furniture, walls, and other stationary objects that a search team finds suspicious. They can also be taken on the road by executive protection personnel.

2.4.7 Portable X-ray

Portable x-ray machines use one of two technologies to obtain the x-ray image. The most common portable device consists of a portable x-ray source and a cartridge containing radiographic film. The object to be examined is placed between the film cartridge and the x-ray source. The x-ray is then shot through the object and onto the film, which costs about $7 per frame. The film must be developed in a separate processing unit, which takes several minutes to produce a photograph of the package's contents. These photographs look much like the x-ray photos used by doctors to examine a broken arm. It takes practice to get a

usable image. Too much or too little energy will yield a photo that cannot be properly evaluated. For example, if the operator uses too little energy, the underexposed photo will be too dark.

A newer technology allows the image to be digitally recorded in real time on a computer screen by connecting a PC or laptop to a plate that receives the x-ray beam. With this technology, the x-ray beam is shot through the package and into the receiving plate, which transmits the image through a cable to the computer. Package contents are displayed on the computer screen, much like the larger x-ray machines operate. This method eliminates the hassle of working with a film cartridge and dramatically increases the functionality of the equipment. The digital technology costs about $30,000.

There are, however, some inherent risks when using portable x-ray devices. Unlike the cabinet or conveyor type x-ray machine, the portable units emit radiation that could cause long-term health problems if the operator does not take the proper precautions. Operators must be conscious of where the portable x-ray is aimed to avoid exposing themselves or others to the beam.

2.4.8 Dual Technology

Dual energy technology is an add-on feature to straight x-ray and will raise the price of a machine by between $4,000 and $10,000. With this option, a second monitor is added that displays the dual energy images. (The first monitor displays images from the straight x-ray.)

The technology can be somewhat effective if used by trained operators. However, the security manager should be suspicious if the vendor claims that explosives are easily detected because they are made of organic materials and will be displayed as orange on the monitor. While it's true that some explosives such as C-4, dynamite, and TNT are organic and will be identified by dual energy technology, many explosive compositions are not organic and will not show up as orange. This is true of black powder, sodium chlorate, flash powder mixtures, and other explosives that are commonly encountered. Therefore, organic/inorganic screening

may provide the operator with a way to separate components of the image, but it will not tell the operator if an image contains explosives.

2.4.9 Scanners

Scanner is a relatively new type of bomb detection technology is the letter scanner. Regular envelopes go through this stationary device past a metal sensor. Scanners cost between $160 and $3,500 and are relatively efficient for preliminary screening. However, they should only be used in conjunction with x-ray machines. A scanner cannot be used to screen boxes on the primary method for sending bombs. It is also fairly sensitive and may beep if a letter contains several metal paper clips. Because some machines are adjustable, operators sometimes lower the sensitivity level to reduce the number of nuisance alarms. If sensitivity is reduced too far, however, the scanner may miss bomb components.

Scanners have potentially dangerous drawbacks. Like radios and cellular telephones, the electromagnetic radiation emitted from scanners could accidentally initiate the firing system of a bomb if the explosive device is sensitive to an electromagnetic field. Although I don't know of a case in which this has occurred, security professionals must be aware of this possibility. The security manager should ask the manufacturer what type of electromagnetic radiation is emitted by the scanner and what impact it might have on explosive devices. If the manufacturer cannot answer these questions adequately, the security manager should not purchase the system. It is also a good idea to ask the local bomb squad about experience it may have with a particular detection product.

2.4.10 Trace Detection

Chemical reagent detection kits cost about $200 and usually include three spray cans. The operator either sprays the package directly or sprays a sample card used to collect a sample from the package. The item sprayed will turn various colors if certain explosive compounds are present. Reagents are insensitive and require a lot of explosive residue to test positive. Reagents may react with explosive chemicals or cause shorts in firing circuitry. In addition, the use of sampling cards subjects the suspect item to additional handling that may cause it to

explode. Although they are used by some corporate personnel, these kits should be left to the local bomb squad.

Most reagents are toxic to some degree. If these kits are used in the United States, the manufacturer is required to furnish a Material Safety Data Sheet (MSDS) for each chemical in the kit. The federal Occupational Safety and Health Administration also issues mandates for proper handling, storage, and use of the kits. Depending on the type of reagents, requirements may include the use of protective equipment (such as gloves, aprons, and eye and respiratory protection), storage lockers, and the posting of MSDSs. Other countries may have similar requirements.

2.4.11 X-Ray Spray

X-ray sprays use a liquid aerosol compound to make paper semitransparent, exposing the contents of a letter or package. Dangerous drawbacks exist, however. Moistened paper may short out an electrical circuit or react with the chemicals of an explosive, causing a bomb to explode. Also, if the explosive device has a photoelectric cell, causing the paper to become transparent could allow enough light to penetrate the paper to initiate the firing mechanism. I consider liquid sprays too dangerous and impractical to use.

2.4.12 Canine

The breed of dogs generally used for explosive detection is English Springer Spaniels and Labrador retrievers. It is vitally important that dogs selected for explosive search work are of sound temperament, well socialized and able to search in a variety of venues and conditions. The ditto two breed had exemplary exceeded from excellence. Once selected, dog and handler undertake an eight-week to ten weeks training course in the methods of explosive detection.

During their extensive training, explosives scents are imprinted into the dog's memory and the dogs are trained on every type of explosive. This means that they can detect approximately 19,000 different combinations of explosives. Explosive detector dogs are trained to passively respond to the presence of commonly used explosives.

Dogs instinctively know how to find things. Handler, the dog's human partner, teaches the dog what to search for. A dog can use all of his/her senses, like hearing, seeing, and smelling to find a specific person or thing. To do this, though, requires a lot of training. They are always practicing, but the dogs love it because it is what they were born to do.
Although, vapor pressures of explosives are very low, parts per billion or less, and require extreme sensitivity to detect. With their super-sensitive noses, dogs are a strong defense in America's war on terrorism used to detect explosives. Scientists estimate that a dog's nose is from 100 to 10 million times more sensitive than a human's.

"There aren't machines sophisticated enough yet to measure the might of a dog's nose," says Paul Waggoner. He directs Auburn University's Institute for Biological Detection Systems in Alabama. "We know that dogs have the ability to detect at least 1 to 100 parts odor in one billion parts of air, but their noses may be even more sensitive." (Dr. Waggoner)

At present, the most reliable method for detecting hidden or buried explosives is using trained dogs. Dogs can discriminate between clashing odors. They can filter out junk smells and zero in on one scent. If your ears were as finely tuned as a dog's nose, you could find your best friend in a crowded school cafeteria by the sound of his voice even if he were whispering.

That means a bomb-sniffing dog could literally find a needle in a haystack - if the needle had a drop of nitroglycerin on it. This ability to discriminate between odors is important to the Federal Aviation Administration, because a terrorist might try disguising a bomb with strong smells like coffee or perfume. But that's not likely to fool a well-trained bomb dog.

A person walks down the street, passes a bakery, takes a whiff, and thinks of bread, A dog passes the bakery and thinks 'Hmm: Flour, water, sugar, salt, yeast.... (Bob Blessing, a longtime FAA dog trainer at Lackland Air Force Base near San Antonio, Texas.) The same sorting of smells happens if someone tries to mask the presence of explosives in a suitcase. An FAA dog can detect dynamite through dirty diapers, or C-4 through smelly socks. Although significant research is underway, we don't yet know exactly how a dog detects the

explosives. Because explosives-detecting dogs require long training and are prone to fatigue, other means are sought.

The secrets of a dog's extraordinary sense of smell have been unlocked. And it's good news, because the discovery could lead to mechanical sniffer dogs replacing the real thing for dangerous tasks such as detecting landmines. Nevertheless, sensors could be mass-produced and, therefore, cost-effective. In the future, they could replace dogs as the primary detectors of explosives. Dogs cannot be strapped to packages, ventilation systems or airport walls. Dogs are complex animals that require training. They need naps, they need to eat, and they can only be at one place at one time. Dog cannot be trained and then multiply it by a million and have copies communicating with each other over a building network.

To find out, Settles took pictures of dogs smelling various scents. As dogs breathe, they draw in cooler air, which is then warmed by their bodies and exhaled. Using a technique called Schlieren photography, which records how gases of different temperatures refract light, the researchers obtained images showing the air currents produced by the noses of the sniffing dogs.

They found that a dog's astounding olfactory success comes partly from its ability to divert exhaled air away from a target scent. When a dog exhales, it moves its nose so that the air is deflected through slits on the side. As a result, the exhaled air flows backwards, away from the smell. This prevents the scent being confused with exhaled air, and sets up a current that pulls new air across the target, launching odour molecules into the air. When dogs inhale they shift their noses into an entirely different shape to draw in a large volume of air.

2.5 Undercarriage Scanning System

2.5.1 what is Vehicle Undercarriage

Vehicle undercarriage refers to the underside of a vehicle. There is no magnificent maintenance required, and is known as the most monotonous part in a vehicle, which are most dirty and least attention among driver. Undercarriage comprises a large piece of chassis

mould under the shape of the vehicle structure. Exhaust pipe is the most significance which stretch from the front till the end of the vehicle. For certain vehicles such as mini buses, van spare wheels are kept undercarriage. Looking from the underside of vehicle, part of the engine is located at the front, which totally contradict from the exhaust pipe location. The following Figure 3 is a self-explanatory of vehicle undercarriage.

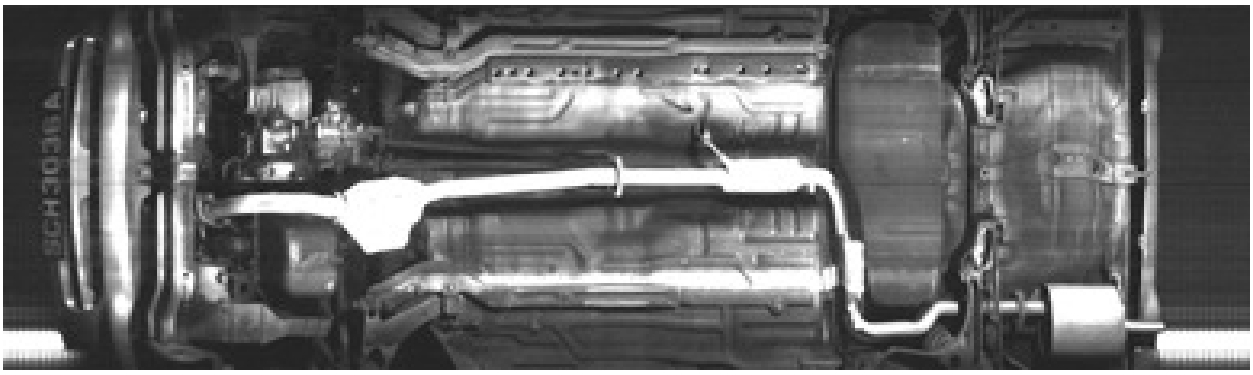


Figure 3: A generic vehicle undercarriage image

Picture extract from (http://www.remotec-andros.com/bodyPages/static/html/andros_uvss.htm)

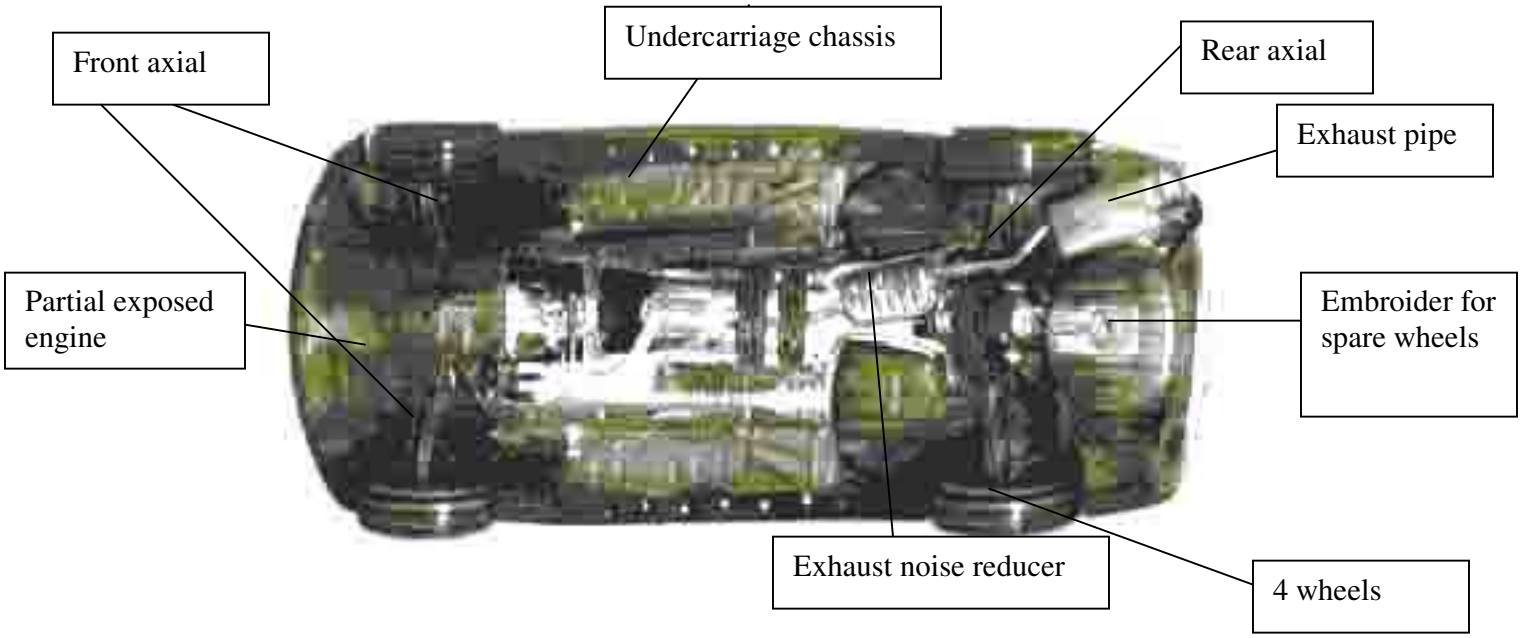


Figure 4: Component of typical vehicle undercarriage

2.5.2 Undercarriage Concealment

To effectively detect possible contraband items, officers have to be trained and well au fait with the expected image of undercarriage. It is vital that officer are not surprise to see undercarriage for their first time and having the knowledge to differentiate between vehicles components and disguised bomb. On top of that, officers should also be vigilant in detecting the possible bombs hideout. Without the essential knowledges, officers are working aimlessly and feel handicapped towards the undercarriage inspection ultimate objective. Therefore, there is needed to equip every officer with these knowledge and detection skills.

Figures 4 show some of the common vehicle acronym and technical parts were make known before deployment commence. Illustrations of possible hideout are also made upfront.

There are 2 fronts and rear axial accompany by 4 suspensions in a vehicle. Anticipating that detection could simply come from undercarriage, terrorists had locate bombs favorably between vehicle suspension and axial. Considering the blind spot from the machine, there could be a left out area and go unnoticed.

By and large, terrorist exploits undercarriage thoroughly to their requirement. In between undercarriage chassis is another common module of operandi used among terrorists. Taking advantage of the top and bottom layer, bombs could conveniently hided in between them. However, the spacing between upper and lower layer are too small for bomb concealment. Terrorists are constraint by the bomb denotation design. Therefore, it was least popular used except for drugs smuggler. Nevertheless, modification are still possible but difficult. It is essential that officers are equipped with such knowledge, constantly vigilance and aware of any of such method.

Hindsight of all, terrorist could also hide bombs in exhaust pipe or embroider for spare wheels. Terrorists removed the least critical sub components such as hollowing exhaust pipe. The hollowing creates advantageous spaces that are used to hide bombs. This is the least possible detection method and could be dangerous. Only highly trained security agent officer could detect the mild modification through the sense of hearing. This is performed through

excellence skills. Till date, there are no capabilities to view vehicles components internally. Scooping will be the next closes method of detection. Officer will use optical wires technology to view in between vehicle small gaps. However, it is tedious and time consuming.

In simple cases, terrorist would adhesive their parcel of bombs under the vehicle carriage. They would convey bomb to their pre planned destructive location prior to activation. However, this means would be vividly difference by duty officer who are also well versed to uncover their plot. Despite their easy detection, it is still favourly adopted among terrorists. Bombs of any shapes and sizes could be camflourage among components and easily attached and dismantled without much inconvenience.

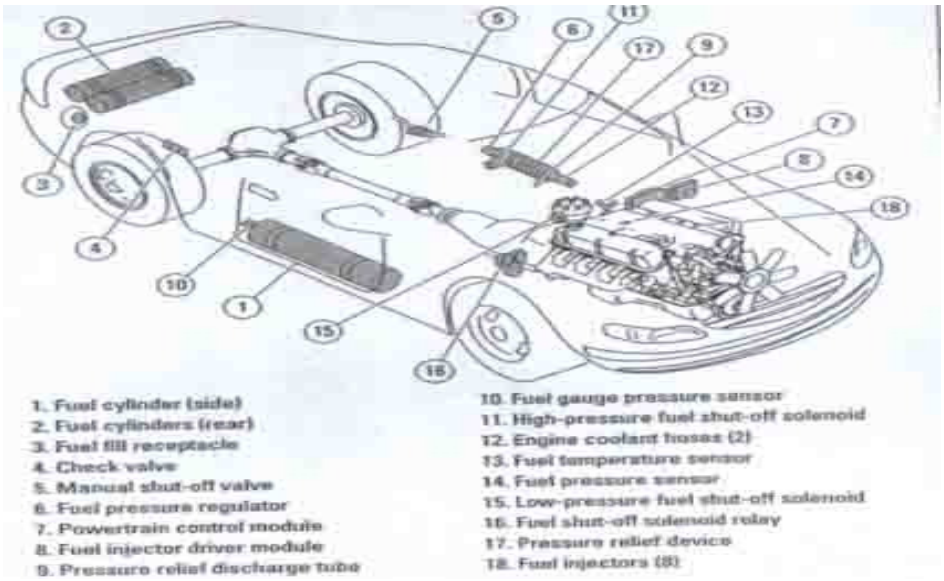


Figure 5: Vehicle overview parts

Through careful studies on vehicle structure, and understanding the overview parts as shown in Figure 5, undercarriage is the least peculiar of all. Comparing with vehicle rear booth, undercarriages are more out of reach in term of search. Vehicle rear booth structured as an empty compartment where possible means of contraband are limited. Compartment used for storage of the contingency wheel is one of the most prominent and frequently used methodologies. However, this loophole had long divulged among security agency.

Considering that contrabands are of reasonable size, it would not be feasible for small gaps and circuits wiring be explored.

Internal vehicle seats are the most conspicuous of all, although mostly distracted by lurxious personal entertainer and car seats. Interior and exterior are merely separated by a piece of transparent glass window screen, where any dubious item could easily be detected. However, terrorists had explored replacing cotton cushion of car seat with contraband. With that as the basic theory, they had modified possible car seat compartment, acoustic board, side drawer, armrest and many more to achieve lucrative or motive.

Considering such furtive hideout, it is deem not possible for security agency to outsmart those hideout, bearing allegation of their liabilities when lurxious belonging are damaged. Nevertheless, terrorists had never know that their strategies are dismissed with the deployment of well-trained dogs. Dogs are generally known to have a great sense of smell. In an enclosed environment, dogs generally performed credibility well and react excessively when contrabands are found. Similarly, air sample in the car could be taken as sample for analysis of present of explosive substance.

Car front bonnet are studied to be mere impossible due to the compact position of engines and other sub components. Audacious terrorists may still try to create additional engine related component hoping to escorts free from the security agency. However, their creation would not be able to escape from the eye of law.

In lieu of the above mentioned, terrorists had cornered to use the most conventional method-undercarriage of vehicle knowing that the smell from uneven petrol combustion would divert the dog attention, knowing that dirt and grease could be camouflage favorably to their key success. Technical study of the undercarriage would reveal that it is hard to reach and deceiving from its monotonous coloured. Understanding the possible ideology, terrorists will try all meant to smuggle contrabands items across in returns of their lucrative or motive.

Through understanding, vehicles ideally transport planned bombs to their destination and only ignite when deems suitable. They are the least conspicuous form of transportation and others would be less feasible. At the same time, vehicle is capable to carry large amount of

explosive, ready to cause massive casualties. Comparatively, motorcycles are too ‘naked’ to concealed bombs. Nevertheless, motorcycle rear box or pannier boxes could serve the same purpose. However, size and capacity may be their only constraints. Vehicles are the fastest and required least amount of skills to transport as compared to massive planned aero plane bombing incident 911.Besides, vehicles blend well among others and caught the security unaware.

By and large, learning experience from previous incident shows that terrorist uses different types of vehicles for different target. Knowing that intervention and resistance could be possibilities present, large cargo trucks are preferred. Generally, large means carry more and often enough explosive to cause devastation to their target even a distance away. As consequence, even if we have managed to gun down the vehicles before attack, the radial explosive are deadly enough.

2..3 A Need to Revamp

Although there are many after market company who have prototyped their undercarriage vehicle scanning system, they were not duly customized to security agency needs. Instead, they estimate and draw their assumption in relation to their requirement. For instances, majority of the company designed their prototype with undercarriage viewing capability. However, mere viewing is not sufficient. This crucial viewed data were lost and not stored for future reference when needed. Comparison of current and latter image was also not available.

Likewise, security agencies were not willingly to reveal more information with regards on their procedure, fearing of possible loopholes and security lapses will be divulged to terrorists and cad. Hence, system was built leading away from perfection. For instances, there were many telltale sign of modified undercarriage with hideout. However, this information was not make known to the system developer in fear of giving them the idea and more rampant of such occurrence. As such, developer had worked within the consignment of mounted camera and not beyond that.

System developer had tunneled their view to only detection of contraband items in vehicle. Sophisticated cameras and system intelligence are trail to out smart these cads. However, maximising manpower with the same or better-achieved quality is as well desired. Current system developer had not viewed industrial automation as a feasible implementation in such security operation. Hence incorporating self-intelligence does not necessary reduce taxing manpower deployment and more.

As the vehicle goes over the Under Vehicle Scanning System that could either be a road hump or an embedded system, be which vehicle undercarriage image will be captured by the camera system. Perceptics under vehicle surveillance system can be a mobile or static unit coupled with its software will capture the images of the undercarriage via the camera installed in the system while the vehicle moves on. The software in the system will process these images to provide a complete undercarriage image.

The system features a 6x zoom capability. The operator can inspect the vehicle undercarriage more thoroughly by comparing the historical and present image side by side from the system monitor screen and highlighting any discrepancies or abnormalities in the images, thus operator can zoom in and out with monitor touch screen

This features sounds practically good and seems that no hidden contraband items would escape from the camera detection. However, zoom capability does not ensure all undercarriages blind spots are within the cameras coverage. For instance, the view of vehicle suspension in well blocked by the vehicle wheels and vertical camera viewing does not show it conspicuously. Knowing the loopholes would mean another avenue for the terrorist to hide explosive successfully through the checkpoint.

The company named uvss.com and Securitex Electronic Systems Engineering has come out with a similar system, which allows viewing underside of the vehicle. It is of robust construction and requires minimum training. This system uses video camera system, which differs from the previous. The system includes a ramp unit and a receiving station, which allows user to examine the undercarriage without much disturbance to the traffic flow. Upon activation, the image capture process automatically begins and the video signals transmit to the Receiving Station. This Receiving Station completes with a processor and LCD screen,

allows monitoring, displaying, recording, and managing the video images easily. A complete undercarriage image displays on the screen, allows the users to conduct a rapid and detailed examination of the vehicle.

Providing video cameras has a specific advantage over digital captured image. It provides a real time views aspects from velocity. However, the frame movement would be too fast and blurry when the distance between the cameras and undercarriage is near. Considering of constant LCD monitoring under such circumstances would means loosing of concentration and focus. Contradistinction would be increasing the distance. That would inevitably increase the ramp height or depth beneath road surface. The latter would not be feasible with mobility as requirement. Neither would increasing the ramp height would eradicate the problem. Question to fonder "What high can we raise the car?"

Remotec Andros Company, which is a current world leader in providing mobile robot systems for use in hazardous-duty operations had also come out with a similar undercarriage vehicle scanning system. From Figure 6 arrays of cameras are deployed below the road surface so as to eliminate uneven road surface or hump to raise vehicle at a height intentionally. Although embedded cameras reduced unnecessary and discomfort while vehicle drove over, much roadwork has to be carried out before these arrays of cameras could be used. Henceforth, it is more suitable for permanent setup rather than a portable one as shown in Figure 7.

Figure 6

Figure 7

Figure 6: Array of undercarriage cameras

Photo extracted from (http://www.remotec-andros.com/bodyPages/static/html/andros_uvss.htm)

Figure 7: Road hump with installed cameras

Photos extracted from (http://www.uvss.com/UVII.htm)

Meanwhile, these images is wireless transmitted to a portable Digital Video Recorder and a LCD screen which can be installed permanently in a Security Control Room or even remotely in a vehicle such as a surveillance vehicle or a police car. Weather camera provides a wide angle and high-resolution capture of video images including the vehicle number and the whole undercarriage of the vehicle passing through it. It can also capture audio signals if required. These systems are fully customized for individual vehicle undercarriage scanning and surveillance application and thus all the systems can be of different specification. They are packed in a robust briefcase for portable and easy setup ability as shown in Figure 8.

Wireless transmission has the advantage of lesser complex wiring between LCD monitoring screen and the undercarriage screening structure. It has sufficient vacant port for future expansion if necessary. However, ever since 911 attacks and recent vehicles bombing, it is therefore recommended that undercarriage system should not run on wireless. Radio frequency might possibly disturb IED or bomb. Only the construction of the IEDs will determine if it is sensitive to such frequency, but will remains unknown at the screening stage. Wireless transmission may trigger the IEDs causing into explosion.

Figure 8: Briefcase undercarriage

Photos extracted from (http://www.uvss.com/UVII.htm)

3.0 Assessment of Consequential Effect

3.1 Environmental Requirement

The connection between sustainability and engineering is not always obvious and easily correlated. However, in today 21st century engineering world, achieving prosperity without destroying environment is the top challenges and all aspects of engineer should work together toward this goal. Scientific should derive efficient way to use energy and raw material while engineer and technician should be skillful to build new technologies, system and process to benefit social and economic. The link between sustainability and engineering clearly explained the involvement from government, university and college courses and through service offered by professional bodies. [5]

As define above, Undercarriage Vehicle Scanning System is categorized as build of new system and process. Inevitably, RoHS (Restriction of certain Hazardous substance) has to be complied. The purpose of RoHS is to restrict the use of hazardous substance and reduce waste management process, which are likely to pose risk to health and environment. Generally speaking, RoHS compliance will switch to new manufacturing process and ban electrical and electronic equipment containing more than the designated allowable substance. In specific:

- Cadmium
- Hexavalent Chromium
- Lead
- Mercury
- PBBs (Polybrominated biphenyls)
- PBDEs (Polybrominated diphenyl ethers)

Preliminary understanding of Undercarriage Scanning System comprises of different section, making up of different material. Thus each designed components materials are to satisfy RoHS criteria strictly. Leads are upmost common used heat conducive substance used in

cables and wiring today. Undercarriage Vehicle Scanning System had no exception from complex cabling with high-generated system heat. However, as environmental conscience, we should not deduce to disapprove cabling in exchange for longer life usage cables. Similarly, manufacturing process and electrical, electronic components should not compromise RoHS compliance in chain jeopardizing our health and environment.

3.2 Ecological Effect

The term environment defines the world around us. The study of ecology examines mutual relationship between the organism and the world, analysis the change and effects on our whole environment due to organism. There is definite a need to enhanced awareness thought, understanding for the future environment that is sustainable. With the use of material grows, environment cannot help but involve an ecological cost of use and cost of pollution of our supportive natural resources. [6]

As a result, Environmental Engineers have the challenge of managing a wide range of problems including toxic waste, air pollution, contaminated land, contaminated water and waste disposal. The public in general had no such specialized engineering knowledge and had left to engineer to act and carry out practice for the general public good interest. Therefore, public entrusting should not be precluded. It is very important that both parties remains mutual trust and practice under code of conduct. Therefore, ecology should be considered prior commencing Undercarriage Vehicle Scanning System.

Ecology experts today think that the earth begun to warm significantly over the past century. It could further increase 3 degree to 5 degree over the next 50 to 60 years. The effect will be enormous. Such warming will cause polar chip caps to melt, thus causing a rise in the sea level worldwide. Global warming is caused from gases in the atmosphere that prevent sunlight from being deflected away from the earth. Usually sunlight reaches the surface of the earth partly absorbed and reflected. The earth atmosphere is only 0.03% Co2 but together with other gases, can trap 30% of the reflected heat and maintain the earth temperature.

Since 1800, an unprecedented amount of CFCs have been released into the greenhouse effect. It destroys the stratospheric ozone, which shield the earth surface from ultraviolet rays. Concentration of carbon dioxide has increased by 25% within the last century. As it worsen, it create domino effect that could cause environment chaos in weather pattern and sea level. Over 40% of all tropical forests have been destroyed and another acre is lost each second.

Initial specification would to design the foresaid system with high functionality. However, green house effect has indirectly created tremendous impact on Undercarriage Vehicle Scanning system. In line, there is a need to reduce the amount of carbon dioxide in the atmosphere. Statistic shows that more than 100 millions Americans live in urban areas where the air is officially classified by EPA as unsafe to breathe. In many urban areas, children are steadily exposed to high level of chronic lung disease, cell damage and respiratory illness. The objective of Undercarriage Vehicle Scanning System is clear, protecting the life and property through detection and diffusion of potential explosive, eradicate massive casualties situation.

Success not only relies on accurate scanning mechanism but speedy method to eliminate traffic queue for security check. Enumerating effect of traffic jam, it had formulated large amount of exhaust gases from vehicle spirally into atmosphere causing proliferation of gases. Obviously, it threaten health conditions and environment suffered unnoticeable, till too late to salvage. For now, the systems undergo additional responsibility of keeping 25% increase of carbon dioxide under control.

Prototype testing would not be omitted after build. Although software analyses are available and pretty accurate, only through testing on the adverse working condition, the systems durability and limit before failure are determined. Similarly, undercarriage vehicle ramp would be put on such test with operating vehicles driving through the ramp under several conditions such as variable velocity and vehicle weight. Finite petrol resources are burned without vivid cost returns till the systems are put into practice. Considering that humankind adds 6 to 8 billions tons of carbon to the atmosphere by burning fossil fuels and destroying forests, pumping up the concentration of greenhouse gases responsible for global warning. (wright, 1995) There is an immediate note for corrective action.

Nevertheless user acceptance test remains vital before deploying full pledge operation. Extrapolation of damage and deterioration over time will reduce long and unfriendly environmental testing. The test result would not vary critically and yet achieving a similar outcome. In conclusion, environmental consideration had replaced conventional testing with sophisticated software and extrapolation technique. An intangible benefit includes reduce resources deployment

3.3 Global Impact In Future Years

As we approached the new millennium with great technologies accomplishments, yet millions of people worldwide still go to bed hungry at night. Development in the Third World is inhibited due to a number of extrinsic and intrinsic factors. The third world countries seek economic and technological help from the First World countries in order to become economically self sufficient. [7]

However, developed nations had portrayed themselves to the Third World as role models of development and modernization. Undercarriage Vehicle Scanning Systems is of course one of the modernization pieces of equipment deployed at security checkpoint against terrorist attack, checking of contraband items prior entry and deterrence of intrusion. This great technology had vividly drawn the lines between the two classes. It would be matter of affordability. Sad to say, the First World nation would get the technology source to fight against terroristism, while third world nations can only use man labour and hard effort but yet poor work productivity. [8]

The debts of Third World countries are high and had estimated to have grown up to $1.77 trillions in just 1993. [8] Lagging behind in area like heath and education, they have limited efforts. Today developed countries have set the membership standard for the first and third worlds. Basically these standards are economic. Many people in the third world believe that they are not allowed to attain these standard because of economic and technology imperialism -costs of Undercarriage Vehicle Scanning Systems are high and unlikely Third World countries were able to sustain.

On immediate note, people in Third World, do not even have the basic Maslow Theory of needs satisfy, not to mention on security issue. Poor economic progress had diffused Third World countries from up keeping technology and had drifts them very distinctively. Contrary, First World nation would benefits from the system capability. It would never be an abandon piece of technologies in centuries ahead nor stagnant, but progress with new intelligence and models operandi analysis.

3.4 Poverty over Technology

The income gap among the people of the world has been widening. These disparities prevail both among the countries and within the people. Because of the disparities, economic cost comparison between Undercarriage Vehicle Scanning Systems and labour hours could not be sustainable. However, it is not so much affecting First World Nation as salary structure are higher, therefore, automation could reduce expensive labour yet achieving the higher quality work output. People in First World nation are generally educated. The substitute of technology over labour work would not be a threat. People are in replaced with a value added work.

For instance, security agent who used to perform manually vehicle access control would now perform monitoring and performing checks only when system detects amiss. In additional, they perform other work alone that would not be possible previously. It doubles work responsibility and increases job accuracy. Nevertheless, it would be foolish to consider robots as one to one replacement of human being with all other equipment unchanged. Such an approach would not take advantage of the robots superiority to human being in certain areas nor would it consider the inferiority of the robot in other area. [9]

Third World nation by and large could be badly affected. Incomes are low. Health and education are in difficulties. Losses of work would means lost of income and devasted the family financially. Third World Nation would not be able to diversify economic strategic and put themselves in advantage.

In today, modern society is hooked onto technology one that gives us life saving hospital units and liberating communication. We are led to believe that there is techno fix for every social ill and global problem. If technology goes wrong, then technology will put it right again. What technology s right depends on the technology that supports human kind in our needs to live in accord with the planet rather than in dominion over it.

Many technologies for sustainability already exit in the form of so-called soft technologies already exit in the form of so-called "soft technology". There is a lot of good technology and the challenge is to create flexible and humane technology. Indeed a crucial factor in this new technology will be its readiness to draw much more on a resource we already possess in abundance human ingenuity.

3.5 Job Gain and Job Loss

As more and more technology appears in an increasing range of workplace, there is a concern that it will take over people's job and increase unemployment. This assumes that the main reasons for introducing computeres are to reduce the need for labour. This simple argument ignores the extent to which new technology does new things rather than changing the way old task are done. Some people have expressed the view that computer are so pervasive that they will inevitably threaten a wide range of jobs. This forecast is not supported. The more interesting is the way that job growth has occurred in areas apparently dominated by computer technology. It is quite difficult to point a significant number of instances where information technology has led to individual losing their job. Instead the result had included a rapid growth in information, advances in the transfer of information and improvement in services. If significant job loss does occur as a result of technology, it may be lower income jobs in manufacturing industries that are most affected. Increased automation means that more can now be produced with less human input. The resulting job loss has affected unskilled workers in particulars. Such change may be offset by consumer demand in manufacturing goods.

While it has been assumed that large numbers of jobs would be lost through new technology, many new jobs would be created to the first. It is assumed that one job lost equals one job

created. People are needed to design and program computers, a level of skill that most workers are never likely to obtain. [13]

3.6 Life Cycle Engineering

Classifying the different version of new product can lead to a great deal of discussion. New to the market products seldom appears in the marketplace. The distinction from other class lies in the fact that such products provide something previously unavailable. [10] The risks and uncertainties apply equally to development of related technologies and subsequent acceptance of the product.

Undercarriage Vehicle Scanning System technology has been known to security agent but never popularized. The technology is never new but involved integrating the functionality of each component into product. There could be several reasons that sequel to the unpopularity. Nevertheless, there is no immediate need to over emphasis new product classification, but could determine the approach used to introduce the product.

Life cycle engineering seeks to incorporate product life cycle into early design stage. These values include functional performance, manufacturability, serviceability, and environmental impact. Evaluation measures for serviceability and recyclability illustrate the practical usage comparing with environmental protection. Life-cycle engineering seeks to maximize a product's contribution to the society while minimizing its cost to the manufacturer, the user, and the environment. Through life cycle engineering assessment, a broader methodology for identifying environmental burdens could arise from a product.

Application of life cycle engineering in Undercarriage Vehicle scanning system is a point factor to consider. System serviceability affects its overall score value and poor score value undermines user confidents. They are especially important in building and construction. According to recent Figures 40% of all materials moved globally end up in, or are associated with, the built environment.

3.7 Ethical, Social Issue

Undercarriage Vehicle scanning system is certainly not the first technology to offer in this radical social change. For instances, steam engine offered new opportunities for social change and for individual action. In another words, new technologies threatened existing distribution of powers, money, rights and obligation and everything worth having.

Technology does not stand outside of society acting upon it. Instead, manufacturer, benefactor users is a social phenomenon to all constraints of other social factors.
Individual will know how to act with ethical, social, political intuition guided by family, education, laws and organization. However, with the introduction of undercarriage vehicle scanning system, there could great disturbance to the tranquility model and part of it may be upset. Political institution also requires time before developing new laws and often requires the demonstration of real harm before they act. [11]

Using Immanuel Kant's Categorical Imperative theory, if an action is not right for everyone then it is not right for anyone. [11] Repetition deployed and usage of Undercarriage Vehicle Scanning System scrutinizes and tightens security level in an agent. It will not have adverse effect on any parties except terrorists mastermind plan. Putting in a vehicle owner position, undercarriage vehicle scanning could be done repeatedly in vehicle owner own comfort, without any extreme cooperation from them. Neither would the vehicle get damage from the contact-less scanning device underneath the vehicle. Contradistinction, if any action cannot be taken repeatedly, then it is not right to be taken at any time, Descartes' rule of change. [11]

3.7.1 Ethical Issue

The ethical privacy issue is invading the privacy of others. What legitimates intruding into others lives through unobtrusive surveillance, through market research or by whatever means. At no time, Undercarriage Vehicle Scanning System doubts on ethical. Although surveillance cameras are deployed strategically, they are strictly used to monitor dubious behaviour among crowds and evidence in investigation if needs arises. Recorded frame would be highly

handled with human rights and reproduction illegally will be refrain. On a side note, surveillance cameras are monitored by management user only and would eliminate abuse. Needless to mention scanning vehicle undercarriage has little or no complicate ethical issue thus far. General public are glad that their safety are emphasis and enforced. Nonetheless, long security checks queue sequel inpatient driver and compliance over the priory.

Copyright and patent rights of the soft and hardware should be enforced. If market penetration is high and enforcement is lenient, functional copy of software discourages developers from improving and envisages deteriorating from efficiency and fights against terroristism. While terrorist progress with new method of attack and concealment, undercarriage remains setback at its own. The core functionality would only be effective till that date and decline towards defeating core purpose. It is a system that requires constant updates and developer's endeavor should never be taken as a one-time contribution. In summary, engineer code of conduct and practice should be mindful and not advantage for the individual.

3.7.2 Social Issue

Society supports tighten security checks but at large concerns the expectation of privacy or privacy practice by security agents. In what areas of life should they liberties and track. There is another article of research stating that surveillance cameras do not improve the situation but adverse on it, especially youth who are already on social marginal. This could subject to greater rebel instead of social adjustment and reduction of victimization. Therefore, discreet or hidden surveillance cameras could be a method to absolve. Dummy cameras served the same effect. Alternative methods however, have one way omit vital social issue and indirectly arouse some unknowingly. Another key of studies shows that public education is feasible. Understanding the consequence and approach views is crucial. Knowing the reliablility of system and data error should not receive much opposed views.

The other negative social costs of introducing information technologies and systems are beginning to mount as technology bounds up. Computer and information technologies can potentially destroy valuable elements of our culture and society even while they benefit us in

another way. Undercarriage scanning system is one of such that culture had been compromised. Culture practice of newly wed couples in cars should not undergo unnecessary stoppage; neither should the bride and groom experiences funshui upset. Causing such is believed to experience huddles years ahead. However, deployment of undercarriage had contradicted between their fengshui and security. The unnecessary checking had inadvertently offended some. Over the time, many unpleased are not heard and learnt to accept loathe.

Along with privacy and property laws, new information technologies are challenging existing liability law and social practice for holding individual and institution accountable. System quality should not be too much aside from the acceptable. Advent from undercarriage, it objective to improve security clearance level through proper ergonomics job and workflow design

4.0 Methodology

Understanding the functionality of undercarriage will help to evaluate existing systems. Through accurate analysis listing of capability and shortcoming, can customized to each and every security agent of different needs. Taking technical specification as reference enhanced our knowledge and feasibility for such modification. The studies of security agent deployment strategic and effect act as a benchmark and distinguish the gaps to success, enumerate amount of work and towards automation. A precise present situation studies is important to avoid future implication.

Undercarriage vehicle scanning system studies are further broken down into components, enhancing and establishing the best in details. In general, undercarriage vehicle scanning system is categories into scanning, computer control terminal, access control and contingency plan. Scanning system consists of ideal cameras that would be able capture sharp images regardless of vehicle velocity and interpolation in details.

Computer controlled system works none other than a processing unit that collate captured images awaiting for further instruction from user. Access control provides the level of security access for each guests and how verification can be done accurate and fast. Ideal access control should not fail and false access should not took place. Determination of forged access would alert the computer controlled system. Contingency plan will include unexpected dash through incidents or attacks. System would go into high priority interruption and execute preventive measures such as barriers to stop intruder.

Integration of system should work with minimum man labour interfering, yet achieving the better work result.

5.0 Risk Assessment

Classifying Undercarriage Vehicle Scanning System according to their risk level is the first step in a process to bring new technology implementation to a sustainable level of management. This assessment will guide both the management priorities and application of policies and ensure that actions are taken according to the needs of the individual. The ultimate aim of the reform is to:

- Achieve clarity about job responsibilities and accountabilities. The management chain is responsible for ensuring individual competence in operating the system.

- Ensure that resources needed are taken into consideration and work effectively.

- Achieve failure of management leadership and communication. Elucidate the impression that mistakes are not incompetent and efficient but worker received no training and technical qualification.

- Ensure that checks and balance are in place to identify that things are properly in placed.

The warning signals from previous incidents were not ignored. [12]
The following risk matrix is used.

Likelihood (How Likely is the event to occur)			**Consequence (Significance of associated environmental impact)**		
Rating		**Definition**	**Rating**		**Definition**
A	Almost certain	Expected to occur in most circumstances	5	Catastrophic	Disaster with potential to lead to collapse
B	Likely	Probably will occur in most circumstances	4	Major	Critical event which with proper management will be endured
C	Moderate	Should occurs at some time	3	Severe	Significant event which can be managed under normal procedure

D	Unlikely	Could occur at some time	2	Minor	Consequence can be readily absorbed but management effort is still required to minimize impacts
E	Rarely	The event may occur	1	Negligible	Not worth worrying about

Table 1: Risk matrix

(Source: Australian/ New Zealand Risk Management Standard: As adapted by Su Wild River 1997 and BCC 1999)

Exposure		
Rating		**Definition**
A	Continuously	Few per year or lesser
B	Frequently	Once or twice a month
C	Regularly	Weekly
D	Occasionally	Few times a week
E	Rarely	Daily

Table 2: Matrix for exposure rate

It is critical to know that risk matrix estimate rather than to measures both the likelihood and seriousness of the risk

A major challenge facing the engineering profession is to design systems and process that are compatible with our natural environment. Encounter that of engineering products that are safe and reliable. More and more companies are being held accountable for faulty products that results in injury and harm to either buyer or public.

Undercarriage is defined as physical vs abstract system- a physical involves physical existing components. It is designed to flexible on both open and closed loop. The presence of the feedback loop that obtain data on system performance, compared the actual performance to the desired performance and determines the modification necessary prior to the next execution of system. Undercarriage is a management control system. We must explicit

provide information feedback to the decision process that control and adjust ongoing activities.

For design ramp to assess manfacturability. Determine process capable of producing the part. The cost of each part (fixed and variable cost). Determine the sequence of operation

5.1 Risk Assessment Charts

Description of Hazard	Likelihood	Exposure	People at Risk	Body Parts at Risk	Consequence
Wrong set up of undercarriage vehicle scanning system components	C	E	Nil	Nil	4 Damaging sensitive electronic components such as sensor

S/N	Short Term Controls	Advantages	Long Term Control	Advantages

1) 2)	Only qualified and trained technician can rectify the system components	Accountability on technicians only	Draft instruction Manual Colored code between connection	User can affix the components from the instruction manual Dummy proof and could easily distinguish

Description of Hazard	Likelihood	Exposure	People at Risk	Body Parts at Risk	Consequence
Vehicles failed to obliged and follow instruction and display. Eg abrupt change lane in congested check point.	B	D	Officer on point duty	All	3 May collide with vehicle ahead and posed danger to officer and others safety.

S/N	Short Term Controls	Advantages	Long Term Control	Advantages

1)	Safety cones to diversify vehicle	Cheap and simple. Temporary and can make changes easily.	Strong LED/warning light and arrows to indicate direction and danger	Prominent and clearly understood to driver
2)			Restraint by roadside kerbs	Drivers forced to follow its lane and confined to lane discipline.

Description of Hazard	Likelihood	Exposure	People at Risk	Body Parts at Risk	Consequence
Automated contingency dash through system activated unexpectedly	E	E	Driver and officers passing by	Injuries can varies depends on eject position of barrier Feet and external limbs can be easily bruised	3 to 5 Unaware hit onto activated automated contingency dash through system

S/N	Short Term Controls	Advantages	Long Term Control	Advantages

1) 2)	Switch off computer controlled contingency dash through system.	Officer have full discretion contingency dash through system activation.	Regular service and maintenance of system	Reduce damage incurred

Description of Hazard	Likelihood	Exposure	People at Risk	Body Parts at Risk	Consequence
Vehicle wheels drove out from undercarriage access ramp	C	E	Vehicle driver	Vehicle may suffered from scratched to damage vehicle parts	3 Audience demand compensation from security agents and suffered ill reputation.

S/N	Short Term Controls	Advantages	Long Term Control	Advantages
1)	Vehicle drive guide to ensure on path	Cheap and easily access, but accuracy is compromised.	Low undercarriage access ramp without compromising the cameras lens	Vehicle damaged are kept to minimum

Description of Hazard	Likelihood	Exposure	People at Risk	Body Parts at Risk	Consequence
Ignition of bomb at security checkpoints	E	E	All equipments and person within the explosive circumstances	Amounting to Death	5 Expected massive causalities and destruction.

S/N	Short Term Controls	Advantages	Long Term Control	Advantages
1)			Isolation of vehicle security check point from control room to avoid causalities and lost of control over incidents	Although attack but communication and necessary efforts resumes.

5.2 Resource Analysis

Components	Availability	Customised	Supplier	Critical	Within budget	Purchasing arrangement
Wire trucking	Easy	No	Computer shops	No	Yes	Computer controlled set up
Cameras tripods	Easy	No	Camera shop	No	Yes	Camera set up
Zoom Cameras	Easy	No	Industrial cameras shop	Yes	Yes	
Hydrogen light bulb	Easy	No	Industrial cameras shop	Yes	Yes	Camera set up
Cat claw	Middle	Yes	Barrier Company	Yes	Yes	Access control
Barrier	Middle	Yes	Barrier company	Yes	Yes	Access control
Proximity sensors	Easy	No	Industrial Sensor	Yes	Yes	Access control
Software						
ANYSYS	Yes	No	-	No	-	Designing of structure
Pro E	Yes	No	-	No	-	
Computers						
P3 2.4GHZ	Yes	No	Computer shop	Yes	Yes	Computer controlled set up
17” Monitor	Yes	No	Computer shop	Yes	Yes	Computer controlled set up
Special Efforts						

Fabricating of steal ramp	Hard	Yes	Steel manufacturing company	Yes	Yes	Access control
Cameras protective casing	Middle	Yes	Plastic fabrication company	No	Yes	Access control
Access control Reader	Middle	No	Industrial sensor shop	Yes	Yes	Access control
Hydraulic system	Hard	No	Hydraulic system	Yes	Yes	Access control

6.0 Project Timeline

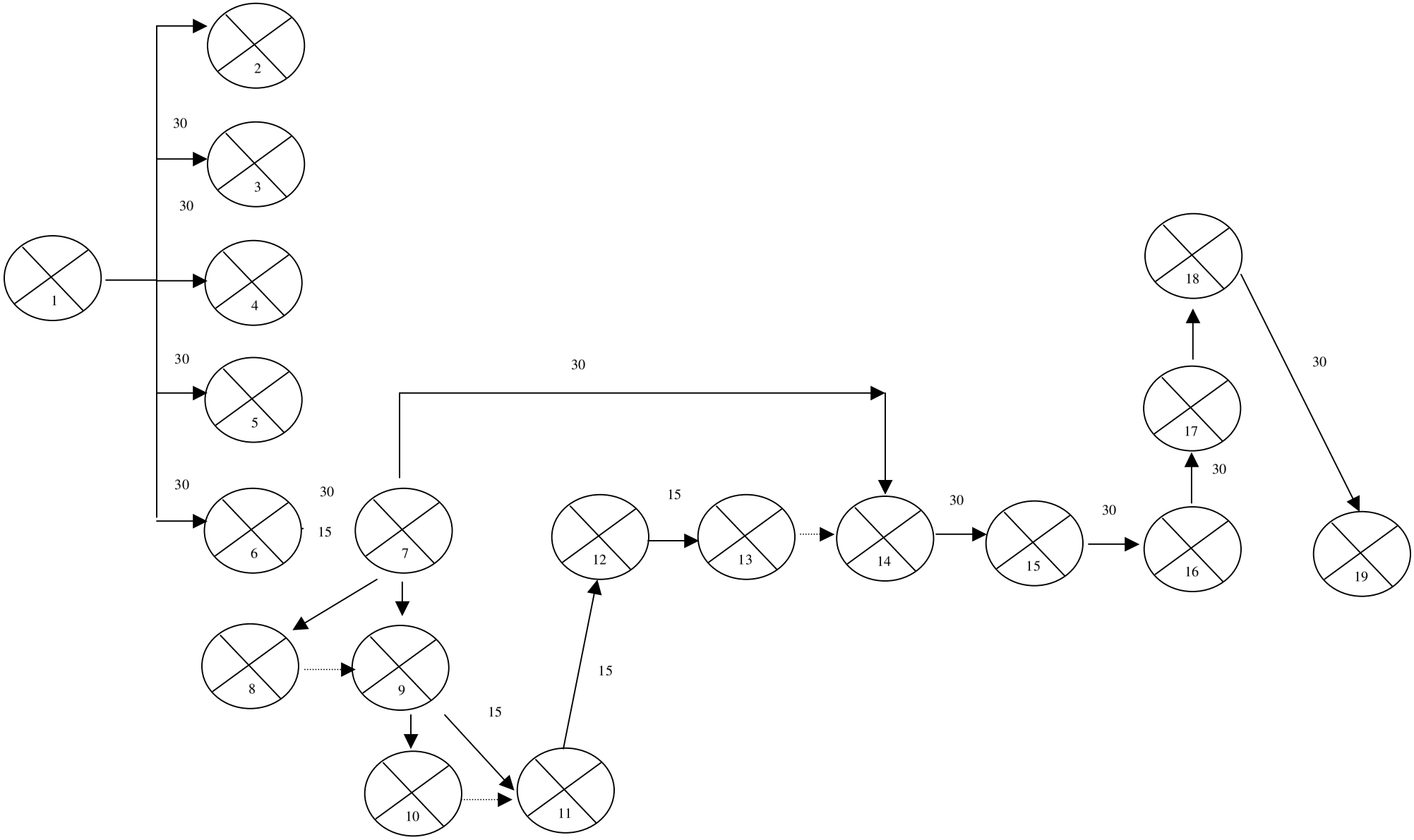
Activity	Activity Numbering
Objective and Literature Reviews	1
Assessment of Consequential Effects	2
Aspects of Ethical Responsibility	3
Methodology	4
Risk Assessment	5
Resource Analysis	6
Project Timelines	7
Functional studies on existing UVSS	8
Understanding the need to revamp UVSS	9
Studies on types of contraband items	10
Method of detection and deterrence of contraband items	11
Current deployment strategies and effect	12
List Desired Specification of UVSS	13
Studies on types of Access control system (ACS)	14
Design of ACS	15
Contingency ACS	16
Design portable UVSS	17
Integration to achieve automation	18
Evaluate revamp system	19

6.1 Network

Activity	Duration (days)	Start Time
1-2	30	0
1-3	30	0
1-4	30	0
1-5	30	0
1-6	30	0

6-7	30	
7-8	15	
7-9	15	
9-10	15	
9-11	15	
11-12	15	
12-13	15	
7-14	30	
14-15	30	
15-16	30	
16-17	30	
17-18	30	
18-19	30	

6.2 PERT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7.0 Deployment and Effect

This following report was permitted by Singapore Police Force (SPF) and is strictly classified as secret. This report is to meant for educational discussion and should not in any way disseminate or publish without the key knowledge of SPF.

7.1 Types of Deployment

Deployments initialed when the need to protect and leverage the sensitivity of the events or function arises. Deployment includes heavy activation and recalled of security enforcer at strategic location to perform security check against contraband items. Essentially heavy infrastructures and equipments are disseminated to perform the essential checks. Deployment hours are usually long and may extend over a few days and months.

In Singapore, foreign or local ministers' functions, functions of equivalent important are deem as high security events deployment. At the same time, massive and sensitive public events such as annual aerospace shows require heavy deployment too. Contradistinction, there is another type of deployment which does not coincide with national terrorists security issue. However, they are crucial and tarnish the lavish image of SPF if not handled properly and tactfully. These are known as operation deployment and have direct impact on national health threat such as Chicken Flu and Severe Acute Respiratory (SARs) outspread.

More than not often, security agent officers are recalled to perform these duties. Working welfares are of course taken care off. However, were left with no alternatives but to return on their non working days. This is of course not always the case. The estimated required strength of officers is temporary taken out from their normal working hours till the completion of deployment.

At the same time, there is static deployment where observation command post had been erected. This deployment is usually for long tenure where shift duties are rotated for high vigilant and resilience look out. Places of weak coastline of intrusion would be seen commonly.

Each deployment varies with threat conditions. Threat condition varies with sensitivity of location and types of on going events, which are predefined. Threats conditions are scaled from level 1 being the lowest threat to 5 denoting highest threat. For instance a Christmas celebration function at a clubhouse with no special guest of honor or parliament personnel will deem lowest threat as compared ministers walking about among the community. From the examples quoted, preparedness varies with threat condition. Threat conditions also rely on valid intelligences information collations of potential threats.

In approving events organized by private bodies, police have to assess the security requirement to impose on the organizers. Police must access the security based on its own merits and make decision to peg events at designated scaled threat. Police will definitely be deployed at level 3 and higher, some from level 2 events and none of level 1 events. If the organizer insisted, police will engage organizer to bear some cost of policing by hiring their own auxiliary police or security/private guards. This is to ensure appropriate control over police resource and avoid diversify of attention when exigency arises.

In low threat condition of level two or one, police will adopt a consistent set of criteria to access security requirement. Police will recommend a fair number of security/ private guards to hire and others look out miscellaneous. No doubt that level 2-threat condition requires only patrol cars frequent visit, it should be cleared and approved from the appropriate authority. As mentioned the threat condition level changes with intelligence gathering.

7.2 Threat Conditions Assessment

Police should obtain a copy of programme or details of the activities and evaluate if they are likely to cause law and order issue or other problems such as noise and littering. If the detection of law and order programme may took place, police are to instruct organizer at interest to modify the programme so as to avoid law and order. Alternatively, the programme is abrogated for public interest. If the response of event in nature is overly reacted, police may pay frequent visit to enhance presence. Concurrently, auxiliary police are to be deploy through the event performing designated task.

Onset, VIP/VVIP presence should be informed forehand. Their presence may result in change of security classification. If parliament VVIP are attending, police have to work in hand with organizer in ensuring VVIP safety. The venue, surrounding and amenities are accessed. Police should look out for concurrent activities or sensitive building, and possible potential threat. An on site surveys will surface better understanding views and police could recommend any access control if needed. If the events are not open to public, organizers are to ensure that only those invited attend the event. For instance, organizer can adopt registration to access control and passes for identification of working staff.

Crowd size should be monitored, in particular on launched of promotion items, artists concert or issuing of free gifts. In events where there could be large number of guests wallowing for attention and possibility of law and order issue, organizer could set up barricade, cordon and queue management. Barricade should be interlocked to ensure that they are not overturned easily. If barricade are set up around stages, it must be at least 2 meters away from the crowds with deployed guards at the buffer zone. In all instances, marshals are deployed to maintain order.

Guards, auxiliary police or marshals should be au fait with emergency escape route and outlet for people to move in case of evacuation. Depending on the sensitive of event, participants may be briefed on the nearest escape route. If event proper does not allow, directional signs and information signpost can help to divert crowd build up. It also allows efficiencies clearance on human flow. Uniformed auxiliary police should be on high visibilities when events include road closure. They initiated to enforced road closure and crowd control. Public should be given grace period to be informed of its closure to avoid unhappiness.

7.3 Security Measurement and Planning

7.3.1 Security Sweep

Police should advice the organizer to conduct a security sweep at least half an hour before the participants arrives. This is to ensure that no foreign objects are found. Should any suspicious

object is found, organizer should tried all means to trace the owner. If the object is term suspicious and unaccountable, police must be called in who will take over the situation. Events will temporary call off till the vindictive of truth. The indication of suspicious arouse greater if any one receive threat calls or any threat means relate to the events. Receiver should remain clear minded and prop as much questions as possible. These questions can evaluate if the threats were genuine. The events will resume once police is satisfy on the absence of threat. If parliament personnel are attending the events, police will perform sweeping and securing with Explosive Ordnance Department (EOD); a team of bomb specialized personnel.

7.3.2 Prowler

Police can advice organizer to form a team of security prowler to patrol all parts of the venue and its vicinity to detect undesirable person and objects. Prowlers should also check for staffs that are not in possession of issued passes. Should any one are detected without a pass, he should be stopped and questioned. Respondent should be allowed to leave without appropriate cause of reason. In cases where working crew are verified to be authentically, they should be lead for exchange of pass. Supervisors are to be informed immediately to rectify lapses if present. If respondent are not able to give a satisfactory account of his presence and action, he should be escorted to office and hand over for further clarification. Prowlers are to remain vigilant for possible suspicious object left after detecting the respondent. There is no compulsory need for prowler to be in uniform. They can be in civilian attire. This has the advantage of enhancing their identity secrecy. Organizer can draw prowling route to intensify critical area.

7.3.3 Screening of Participants

With the need of tighten security measure and detection, police can suggest to procure hand held or walk through metal detector, explosive sniffer and desktop X ray machine on bags and personnel belonging. Participants are make to queue in a orderly manner. As they approached the equipments, theirs belonging are placed on these equipments which can effectively isolate contraband item, fast and accurate with minimum inconvenience caused.

Its advantages are needless to explicit. Embarking of these equipments would indicate only entrance and managed participants in a control manner. Any detection of contraband items can be divert to baggage counter for the participants to deposit their handbags or prohibited items before proceeding into the function area. These items can be claimed back at a latter stage.

Personal carrying in pockets etc will only be checked if the equipments triggered an alarm. Otherwise, participants could proceed without delay.

7.3.4 Securing of Car Parks

Police could recommend added security measures such as making sure that cars are parked safe distance away from the event area. Securing of carparks and parking away from the events are effective means to ensure that no one uses a vehicle to transport bomb to event area. This tremendously saved efforts on checking vehicles for bombs and could diversify manpower and time on participants' bags for contraband items. Organizer may also planned prowler route along main road to look out for illegal parking vehicles which could contains bombs awaiting for best time to detonate. Organizer may wish to secure basement carpark that is directly below the function area to prevent any vehicle from transporting a bomb into the car park. However, special guest of honour vehicles could be privileges to enter and park. Organizer may wish to discourage guest from driving private vehicles into area. In return, buses and coaches are catered to send them to the nearest car park. Organizer can consider restricting parking.

7.3.5 Medical point and Emergency Access Routes

For events with large turnout, police should advice organizer to set up medical points and stand by ambulance in the vicinity. In situation where there are casualties, they could be promptly attended prior conveying to hospital. Signboards and directional signs should clearly explicit medical point. Neither should it be obstructed. It is important to maintain clearance and clear indication in times of emergency.

Despite medical preparedness by organizer, police should not omit the possibilities of massive casualties and evacuation. If the venue allows, police should have predefined unobstructed space for emergency evacuation and setting of search and rescue point. Special requirement and contingency operation plan should be forecasted prior commencement of events.

Where possible, organizer should also forward a copy of building or venue blue map to fireman and police department with highlighted escape route. This information is vital when search and rescue are conducted. It streamlines search process in a better-managed manner.

7.4 Manpower Consideration

Learning from the previous topic, police and organizer will collaborate to ensure safety of VIP/VVIP. There are many security measures to enforce. The aim of security checkpoint is to check on participants' baggage and possession of contraband items. Current technology and methods allows checking on individual to be fast and accurate. However, time lapse and inefficiency on the vehicle check. In this thesis, we are emphasizing only on vehicle checkpoint. Vehicle checkpoint could be temporary or a permanent set up station before entry into sensitive place of interest or installation. Its sensitivity and threat condition will be predefined as explain on previous topics.

The location is firstly accessed on security concerns and preliminary strategic planning is laid upfront. Security concerns includes looking out for flammable factory or condensed residential or schools nearby. In order to access its importance, a recommended questions asked, "will this features escalate into higher death and casualties count, or slows down rescue work? If the answer is definite yes, police have to work diligently to overcome. Strategic planning includes layout of emergency civil wok station and the location of security checkpoint. Ideally, it shall be set up solely at one entrance where there is full control. The number of vehicle checkpoint depends on the expected crowd size. In general rule of thumbs, checkpoint should not result in heavy congestion, causing unhappiness among participants. On the other hand, police are bottom down to the manpower and availability of system.

Understanding the role of each officer provides clearer views on why there are lapses of efficiency. Identification of improvement or system control could be easily recognized.

Referring to Figure 9, three to four officers are deployed to control the access right of vehicle entering. One of the officers will perform as an over viewing role and doubling as leader. He will divert the flow of on coming vehicles to available security checkpoint. Bearing in mind that officer is working under hot sun where they could not be possibility sheltered. At first sight, officer's duty is simple. On high attention, he has to execute directions hand signs as soon as he sees the car approaches. Failed to will cause unnecessary stopping and causing congestion in peak period. In worst situation, car accidents could take place. Officer has to maintain constant eye contact with driver and through reading of drivers' body language and vehicle control to mutual understanding.

Being a leader, he is to remain high vigilant and provides sufficient warning and information to the subsequent crews behind him. His critical duty is to observe for suspicious car and provides early stoppage before entering into the check zone.

When the vehicle had been channeled into the check zone, the second officer will be hand signaling on car driver to inch forward or stop as required. This is to ensure that vehicle maneuver are under full control and minimize possible threats of dashing through the check zone. Officer in front of vehicle possess great danger because a desperate terrorist may brazenly knock down who ever on his way. Officer has to remain high alert and take total control of the vehicle.

While the vehicle comes into a complete stop, 2 others officers are to conduct full pledge under vehicle carriage search using conventional undercarriage mirror. The latter officer will proceed to take down particulars of the driver with visual interior search of the car. Affirmative on its clearance, this car is termed code 'green'. It is now channeled out of the check zone to his destination.

Nevertheless, along the route to his destination, barriers and road humps are set up deliberately to build slow traffic. This purposely allows interception if there were any escape cars. Undercarriage screening process is streamline and congestion is kept to the minimum

when there are no potential threats. However, bomb threat can be made anytime. Actions taken to mitigate the threats also have potential disruption on operations and undermine public confidence. Police actions have to consider the risk level and potential disruption to the public. Officer responding to such similar bomb threat have to access the sensitive of the environment. Officer should note if other country of a common location or building in nature had been bombed and targeted. Officer should verify intelligence gathering against source of threat. Should a search be called, more manpower is used to affect the search.

When the search discovered an unclaimed parcel, ground assessment is vital on the next cause of action. A minor categorized will result in small detour with no disruption to the events or business. Depending on the situation, it may be setting up small radius around the immediate vicinity of the object with little disruption. When its situation is upgraded to medium, the normal activities of person and business are mild disrupted. Events and operational task may be terminated with manpower diversify. Subsequent major category will caused the largest amount of disruption with to the public and daily flow of errand.

In the events where no bombs are found yet, officer should evacuate at least 15minutes after the time given for explosion. Officers shall return to search only after 30mins from the time given it is expected to explode. After confirming that it is a hoax, officers shall then continue. If an unclaimed parcel was found, EOD trained officer shall make assessment to eliminate suspicious. EOD trained officer should deployed the use of sniffer and other suitable equipment in determination usage of bomb suppression Blanket and activating of EOD specialist.

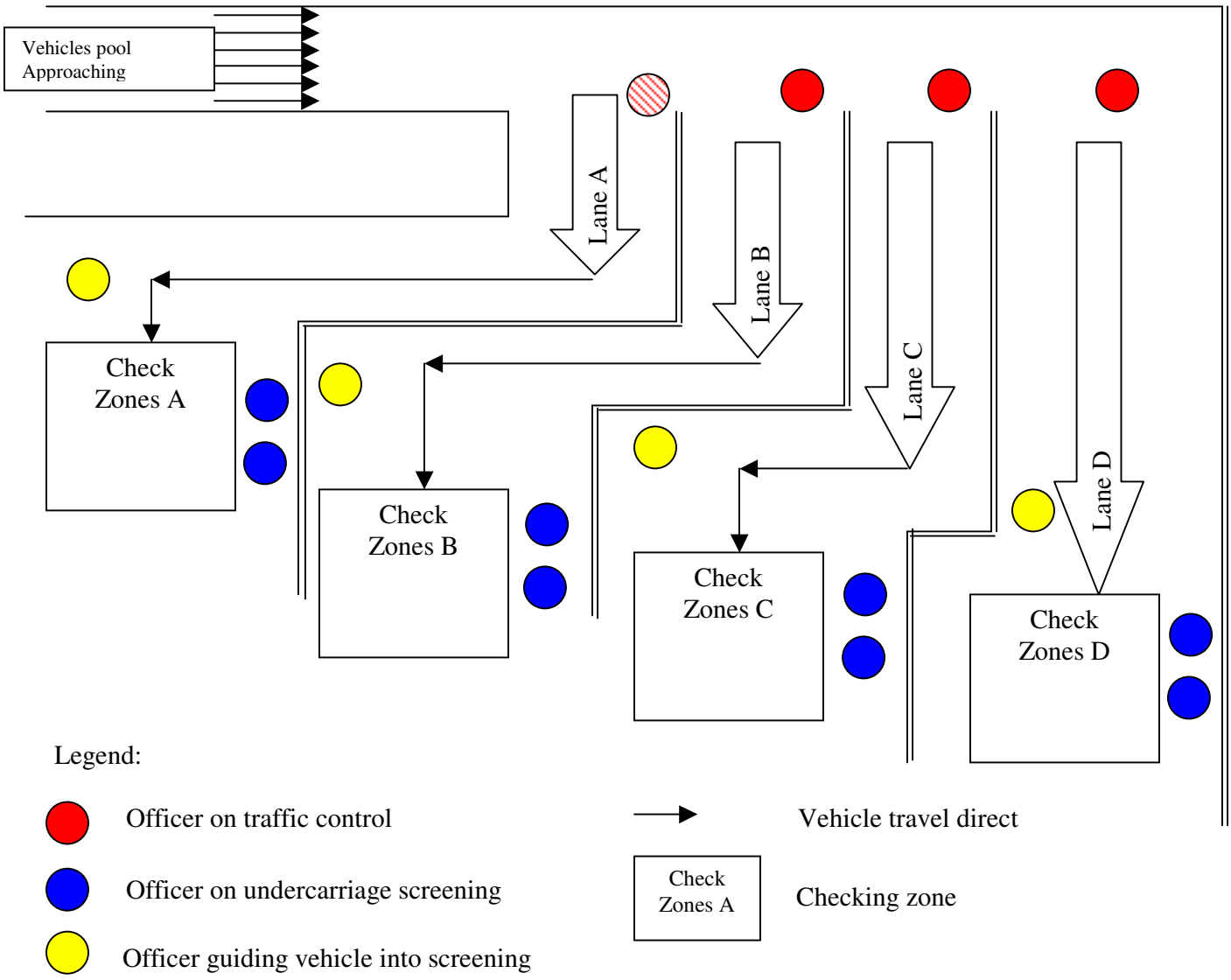

Figure 9: Four Lanes manpower deployment

7.5 Effects and Contingency Plans

Major disasters are sudden accidents involving the loss of lives or damage to property on a scale in excess of that which emergency response agencies can deal normally. Depending on the type and location of incident, various agencies have to be activated to participate jointly in rescue and recovery efforts.

The joint rescuer plan requires the set up of various workstations to support the search and rescue, investigation and recovery operations. One of the more critical and difficult tasks is the tracking and management of the casualty figures. There would be issue of coordination on casualty figures by different agencies, as casualty figures would be scattered at different workstation. Casualties may also flee the scene immediately after an incident (and seek medical attention only later) before the responding agencies have set up their workstations. Injured casualties may subsequently succumb to their injuries and even the number of dead may initially be uncertain as body parts may be scattered. There would be time pressure as the public and media demand for information on identities and number of casualties to be released. Therefore, there is a need for incident manager who will be responsible to collate casualty figures. It is critical that clear demarcation of responsibility be carved out so that agencies have clear understanding and ownership of responsibilities. This will not only prevent duplication of efforts but also more importantly reduce collation errors. It will provide single points of casualty information collation ownership for various casualty figures at various workstations and location.

Different agencies will collate figures of death, injured, injured and missing. Death casualties simply mean those that are found dead at the incident site and will not be removed until they are dealt by the forensics team. Thereafter the dead bodies will be conveyed to body holding area for identification and processing prior sending to mortuary. There will also be injured casualties who may die en-route or succumb to their injuries while being treated at the hospital. These en route bodies will be referred to police investigation officers deployed at various hospitals.

Uninjured persons will be directed to the Uninjured Holding Area manned by the police. Police will conduct interviews before releasing them. Their witness and account are vital as it provides leads and information to the incident and police investigation. It is thus important to secure their interview prior leaving the scene and failed to return for cooperation when is needs

Injured persons will be brought directly to the first aid point for triage. Medical teams will categories the injured causalities into 3 priorities according to the seriousness of injuries. The

least injured will be taken away for interviews after medical attention, while the more serious ones will be rushed to hospitals.

Missing persons are those that deemed not under any of the above at the point of incidents. It will only be classify otherwise after certainty of identification or till proper investigation satisfied so.

7.6 Factors and Limitation

Every event deployment taxes heavily on manpower. There is no alternative to relieve these heavy deployments. Therefore, there is a urgent need to automat vehicle screening process while officers' core duty could be diverted into monitoring and performing others duties where technology are yet to take over. Automation improved the services and performance. Comparable to system, it does not deteriorate efficiency over time where human does. Nevertheless, system hardware obsolete when new hard wares are introduced.

User cautious input of information will generate accurate information. For instances of emergency situation, officers performing rescue and search in chaotic situation needs strong control of information to establish possible unsaved casualties. Therefore a master list of people attending the events could make data collating efforts simplified and efficient. Overall, it improves capabilities and performance securing accurate data. Along side, it may be expensive to operate or maintain as a result of technical problem, design weakness or changing requirement. It might be possible to adapt new system to newer technology or upgrade it. On the other hand, cost benefits analysis might show that a new system would be more effective and provide better supports for long term objective.

Internal and external factors affect every decision that an organization makes, an IT system projects are of no exception. Although users rely heavily on system to perform their job well and are likely to request for IT supports, top managements are the prime source of large scale of system projects. The management sets strategic plans and the overall direction, which has an important impact on IT projects. IT staff members also make recommendation based to their knowledge of operations and technology trend. Therefore, IT staff members make

important decision on the procurement of system. A good, friendly, easy operated system makes works and user easier yet producing optimistic productive. While a wrong system inconveniences and doubts data accuracy among end user.

Changing technology is a major force affecting the growth. Nevertheless, technology had dramatically reshaped existing operations. Most organizations have a mix of software and hardware that must work together effectively. As technology changes companies make decisions that trigger system requests. Simply, there is not off shelf purchase system that served user requirement and specification. System customization is the only way to ensure well coordination among each other.

7.7 Conclusion

Although it is vivid clear that police are only deployed on threat condition of level 2 and above, there is a great number of events that falls under these categories. Regrettably, large numbers of officers and equipments are involved. It resulted a greater need to ally the taxes of manpower through use of appropriate system and methods.

Alternatively, the threat condition could be re-assessed and tantamount appropriately step up security effort. In another word, security effort could be out source to relevant guards to reduce heavy utilization of undercarriage and manpower deployment.

While it is noticeable that great security efforts are taken prior entering into designated area, consequence of event could have been arranged to better meet the end. For the additional effort to secure car-park and prowling, undercarriage inspection system could have been better use to reduce the unnecessary.

Contradistinction, the introduction of Undercarriage Inspection System, should not upset its procedural work process too much and carries much of adverse effect than help. Therefore, knowing the procedures forehand could affect the desired functionality of Undercarriage Inspection System. Likewise, the physical system appearance might obtain its influence from

externals factors. Therefore, there is a requirement to understudy the current deployment strategies and how the system could be use of great use.

8.0 Access Control System

8.1 Access Control

Access control is analogous to locking the gate and only allowed those rightfully by sole arbitrary conditions, which may or may not have anything to do with attributes of particular visitors. There are 3 distinct ways of dealing with a particular genuine request. They are namely Authorisation, Authentication and Access Control.

Authentication is any process of verifying that some one who he claimed to be. This usually involved a user name and a password. Secondary level includes demonstrating identity such as smart cards or even fingerprint. Authorisation is finding out if the person once identified is permitted to have the resource. This is usually determined by finding out if that person is part of a particular group where physical access or admission is possible.

Access control usually refers to perimeter protection and could be as basic as a low security door. Security door with electrical connections qualify electronic access control system action. For this reasons, there is a requirement to understand the dangers of working with mains electrical cabling and the regulations as they apply. In additional many building have multiphase supplies and the means by which they are derived should at least be understood even though there is no practical need for the access control engineer to work with them unless heavy duty motors are to be used to power barriers.

The extent which system can be used and the complexity of its software are very much related to the equipment. This primary equipment has an influence on the cabling that are to be employed and will differ between the equipments used. The length of the cable runs along the current consuming devices. In certain circumstances, there will be a need to incorporate additional power supplies and every case attention must be paid to suppress electrical interference, which can corrupt data. The cabling must be mechanically protected to withstand anticipated degree of abuse and to achieve the correct degree of aesthetics. Consideration must be equally applied to environment condition for all system components so that they fit their purpose in the environment.

8.2 Access Point Hardware

The technique of protecting the perimeter at the access point is achieved by hardware. Hardware is the components that enable access to be effective through a designated point of entry. There may also be a need for protection against unauthorized tailgating behind an authorized entrant and attempts to gain entry by close contact with the former person. The protection against tailgating can be afforded by turnstiles or air lock door techniques. Vehicle access rising kerbs and bollards can be employed although understood that these give no protection to pedestrian traffic restriction. If low security access is needed to control pedestrians with vehicle, there is a better range of barrier available. Security can be effective with combination of physical measures such as walls and fences plus any electronic security such as intruder CCTV and lighting. These measures are needed before determining the requirement of access control system. The perimeter must be secure in relation to the level of access security needed.

In practice, almost any barrier should be automated so that existing gates of originally purpose could be adopted into access system. Although all vehicle barriers does delay authorized access, they do not necessarily prevent it and it must be understood that for a highly secured barrier, it has continuous surveillance. Lightweight gate are indeed often used if ice can impose a hazard or if there is concerns that a vehicle can be hit another causing it to collide within a barrier

8.2.1 Crash Barriers Control

An aspect that must be fulfilled with all system is the installation of a locking device. All locking device must have the capability to be unlocked electrically and must be monitored for their status together with the position of the barrier or doors that they secure. This could be done easily with a structured barrier control. Lack of communication protocol among other security checkpoints is crucial. Terrorists could dash through the security checkpoint at ease with barrier status unknown. Thus security checkpoint shows futile effort.

Barriers form a separate security role and they offer little resistance to determine human intrusion but intention to control vehicular traffic. Although any barrier can in theory be automated, the electrical requirement for this function varies from low voltage drives to mains power multiphase motors. There may also be certain heavy construction building foundation tasks to complete for high security barriers and this demands specialist attention. Nevertheless, barrier cannot inflict damage on obstructions that could be positioned within its movement path.

8.2.1.1 Turnstiles and Paddle Barriers

As shown in Figure 10, this form of barrier decreases casual piggybacking by forcing people to enter one by one and is further enhanced by the use of alley or narrow lanes. These lanes are only able to hold one person at any given time. For high security risk entrance, secure vestibules and turnstiles may be used. It has glass portals that hold person in a sensing area, enabling them to be visually verified before access is granted.

Figure 10: Pedestrian turnstiles

(Picture extracted from www.storefixtures2000.com/CrowdControl)

The actual barrier type will be governed by factor such as aesthetics and whether security guards are present. In the event that the barrier can be vaulted, a movement detector can be used to monitor the area above the barrier. This sensor is only enabled if the barrier remains closed. For external operation where aesthetics are not important, full height barrier can be used, as shown in Figure 11

Figure 11:Pedestrian height turnstiles that disallow force through
(Picture extracted from www.abacos.co.uk/turnstile.htm)

8.2.1.2 Rising Kerbs and Bollards

These elevate from the road surface to restrict vehicle access and are often also called pop up barrier or kerbs, as shown in Figure 12. They have high levels of impact abuse and are rapid in operation. These devices may be increased in number of work in tandem or to form a wall of protection.

They can be used in landscaped areas and business parks but must be used in conjunction with 'stop' and go light suit to low visibility, as shown in Figure 13. Switches are used to confirm that the unit is retracted and drainage must be installed to take away water from the underground mounting positions.

Figure 12: Active rise kerbs.
(Photo extracted from www.highland-security.co.uk/.../rising_kerbs.htm)

Figure 13

Figure 14

Figure 13: Interlink bollard with signboard

(Photos extracted from www.woodscape.co.uk/bollards.htm)

Figure 14: Bollard with bicycle-parking stand

(Photos extracted from www.funkypancake.com/blog/archives/cat_bollards.html)

8.2.1.3 Gates

These tends to be used to control vehicles access and requires a large flat surface on the side of the gate through which it must swing, because of this they are not practical for some application. There is a large amount of movement needed to operate a swing gate and opening and closing times can be excessive. Indeed many motorists could feel intimidated if the gate movement was too rapid when the gate was opening towards them. A further consideration is that space must be allowed for opening arc of the gate and waiting vehicles. The reader must be correctly sited at the position at which is held for verification.

Although it is possible to use gates, which folds as they open to save space. The most commonly used option is to install two smaller gates, which save a great deal of space in the opening arc. The only disadvantage lays greater cost for double gates; the installation is 2 units rather than one and the extra cost of the electric drive or hydraulic unit that powers them. Swing gates also have low impact resistance but remain popular for low to mid risk security application. Sliding gates are commonly used in vehicular access control system sliding gates and used when space is at a premium. They are seen sliding parallel to the security fencing and walls.

The tracked form of sliding gate features runners guided along a steel track that is formed in concrete on the ground surface. It is extremely strong as its weight is supported in the track

and the only main consideration is to ensure that the track stays clear of obstruction and is periodically cleaned. Other than that, others are not of much impact resistance to the swing gate.

Cantilevered sliding gates are also self-supporting. They are held at one end by a strong supporting framework. They are disadvantaged in their weaker resistance to impact. Nevertheless, maintenance is reduced, as there is no track to keep clear.

Although swing and sliding gates can be used to control the access of both vehicles and pedestrians, the rising arm barrier can be employed if pedestrian traffic is unimportant since it provides a quicker means of operation at a low cost. These are sometimes also called pivot gates or barrier. Standard and industrial strength version are available although neither provides high impact resistance. The arms are designed to break on impact to reduce vehicle damage. The industrial version has a longer span and is capable of withstanding a greater level of abuse and a certain degree of impact. In underground car park, arms can be deployed, as these need less headroom to operate. In the events that pedestrian access required metallic curtain, it can be added to the barrier. These collapse as the barrier rises so that there is little obstruction to high-sided vehicle. In the down position they give good resistance to pedestrian penetration.

8.2.1.4 Air gate

As shown in Figure 15, this is a low security pedestrian or vehicle entry system without any physical barrier that notifies the security personnel at the reception point. The access is made successfully through a beam detector provided that the entrant has a token, capable of being verified by radio frequency (RF) receiver unit.

The system comprises of beam detection unit, senses both pedestrians and vehicles and aerial loop buried in the ground. The access point senses RF transmission and authorized tokens.

- On crossing the buried aerial, pedestrian and vehicles is interrogated to ensure a valid token is held.

- Providing a valid code read the beam detection unit, which is disabled for a prescribed period enabling entry to be made.

If a valid code is not received the beam unit gives an audio or visual output to alert security personnel.

Figure 15: Air gate

(Photo extracted from www.kaba-gilgen.ch/seiten_f/.../news_9_f/news_9_f.html)

8.2.2 Identification

There are 2 main category of identification. Identification through knowledge derived from a code or PIN entered into a digital keypad. These form the keypad entry system technique. Identification through possession, based on the holding of mechanical key which has a code held within its construction either in its notches, grooves or dimples or by data being encoded into a card or token. This method also covers non-contact identification.

Single identification method is sufficient and secure. However, when extra levels of security are needed, combination techniques can be adopted. To explicit, a number of different technology systems must be satisfied simultaneously or within a prescribed time limit before access is granted. The most common of these is card plus code where the person attempting to gain entry must hold a valid card and have an authorized PIN. Therefore any potential entrant has possession and knowledge.

All identification methods have advantages and disadvantages. In practice they also have inherent level of false accept and false reject. With dual approach techniques, there will always be a higher level of false reject than false accept. Code identification systems have a lower level of false accept. Code identification systems have lower level of false accept and false reject but these factors are attributed to the user rather than to the equipment. Knowledge based system are therefore inherently reliable in themselves but must trust the

user to address the problem of spying or casual observance being employed by others. In possession based systems are governed by card, key or token, which are concerned over damaged and stolen. In another aspects they are both reliable and durable.

Personal characteristic or biometric systems are more complex. They are developed to negate the problem caused by the duplicating of tokens and authorized access being gained to PINs. Although biometrics are highly secure they must have higher level of false reject and this percentage value must be set in the equipment to keep the level to an acceptable minimum. The more onerous the acceptance criteria the greater the chances of the rejection of valid entrants whilst lowering the acceptance criteria may lead to false accept.

8.2.2.1 Token and Reader

Token is effective because the components are used to identify user to the access system. In electronic access control, the term token is also referred to credential. In broader terms, it is documents that verify a person identity whilst the person who presents the credential to the system is classed as being authentic. Credentials are referring to cards, tokens, proximity tags and physical behaviour patterns or biometrics. A token may also be regards as a sequence of number or PIN (Personal Identification Number) typed on a keypad. In the industry, many different terms are used. Cards and tokens are presented to media reader for authentication; biometric elements are presented for verification. When any of these is validated, access is granted. Consider the common use identification method, which are used to discriminate between authorized and unauthorized personnel access to a given point is allowed. This method extends to non-contact identification and personal characteristics or biometric system.

Identification are presented to an electronic reader and then automated into the access control system. These techniques differ according to the application and level of security required. The decision made by the reader determines the action that the system will take, be it to grant access or to generate an alarm condition. Entry can be granted based on the knowledge that user has before allowed entering. It may also be granted base on possession because the user carries a token or tag that is regarded as authentic at that period of time. The other condition of entry could be physical attribute that the reader accepts.

When higher levels of security are specific the different technique can be amalgamated so that two or more different conditions must be satisfied simultaneously in order to gain authorization.

8.2.2.2 Code Identification System

As shown in Figure 16, it is extremely versatile, durable and inexpensive. It operates by validating the presentation of a code entered into its keys. The code is generally numbers of four to ten digits with errors or deleting being made by use of additional keys. The keypad may have additional keys identified by letters of alphabet for special functions.

The coded keypad is easily understood and not difficult to maintain as it features little hardware as a single technology, although it will also be found combined with other technologies to provide a dual approach. The security of the keypad and system is very much related to the number of keys that make up the limit and the number of digits that form the code. A realistic level of security is offered by having 10000 possible code combinations. It is possible to overview the number of combinations of a system.

There are a number of methods employed with coded keypads to increase the difficulty of authorized person trying to gain access through them. Keypads with scramble functions address the problem of spying by randomly changing the key top labels. These units comes with a preview window showing which keys apply to the different numbers so that the finger patterns of entering the code into the keypad regularly change. Alternatively, warning lamps or audible sounders can be linked to the keypad to deter persons who may attempt to enter multiple numbers at random in order to search for a code. Equally a local sounder is normally adequate to stop an authorized person tampering with a keypad as it brings attention to the area.

Timers may be incorporated in the keypad to extend the time taken for the keypad to respond if an incorrect code is entered. This method effectively closes down the system on each occasion that a wrong digit is entered and therefore extends the time that an unauthorized person must spend attempting to cheat the system or find a PIN.

Other consideration are that for security to be maintained, keys are to be regularly cleaned so that the keys used in a PIN and those keys that are unused are not identified as such by their appearance. Code changing should always be performed on a rotating basis and this will be found to be programmable at the keypad or selected by the use of jumper or links. It is understood that certain code system will have one code only for all users whilst others may have a multiple for different numbers interfaced with a central computer. However, if there are great deal of interfaced with a central computer. Otherwise the access control is seriously reduced because of the volume valid code that exist. This combined card system is an option to use code and keypads featuring a greater number of digits.

Other technique includes common pass code entered into the reader before the card is used. The card is then used to identify the individual with the reader linked to a data gathering system. It will be found that the variety of keypad and options is enormous and range from basic low cost unit with simple functions to vandal resistant devices with high levels of environmental protection. The main advantages of the coded keypad are:

- Compact and easily understood.
- Different code may be used to give access to different points and doors.
- Maintenance is easy.
- Not expensive. Easily replaced or repaired. Little complex hardware is needed.
- No cards or token need be carried so there is nothing to loose or forget
- Can be supplement with alarm and timer monitoring
- Can be combined with other technique following a common code being entered
- Reliable
- Programming is straightforward.
- The disadvantages mainly governed by the user needs to be vigilant to avoid code to be viewed by others. Hands free are also not an option with the coded keypad. Card based identification system relies on the reading of a token that may be a card, key or tag. There are a number of technologies that govern the level of security offered and the durability of system. These items encoded (have their information stored on them) by special manufacturing equipment and must have acceptable level of resistance to copying or

transfer of this information onto other cards. The resistance to the problem of copying and the physical resilience of the card itself vary between the different technologies

Figure 16: PIN Identification System.

(Photo extracted from scd.hitachi.ca/aspx/pub/CompDiv/Page.aspx?id=50)

8.2.2.3 Magnetic Strip

Magnetic strip card is in fact the most widely used card, especially in the banking sector where it is used for credit purpose and bank automatic teller machine. They are inexpensive, easily manufactured and encoded and carry alphanumeric data. They are also the most common access system card and consist of a magnetically sensitive oxide strip fused onto the surface of a PVC material.

The card is encoded by means of magnetized and unmagnetized on the strip forming the binary code. Changing the orientation of the north and south poles of the magnetic materials and using the transition distances between the poles to store the data. The magnetized and non magnetized areas are represented by the number 1 and 0 to form the appropriate binary code which is deciphered by the reader on presentation. They are manufactured from high coactivity that is a measure of their ability to resist corruption by stray magnetic fields with high coactivity cards being most incorruptible. Coactivity force rating indicates the strength of the actual magnetic field that is needed to ease magnetic materials and range from 300 oersted for low coactivity through to 4000 oersted for high coactivity. The durability of the card can be further increased by manufacturing them from a base material of polyester/ mylar laminate in preference to PVC.

Magstrip card is available in many different formats so it is able to contain varying amounts of information and in operation it is extremely reliable so error rates in readers are low. Magstrip is disadvantaged in that it may be physically damaged by misuse and its data can be affected by magnetic fields even when they are of only low potential. The other problem includes high volume of equipment available for reading and copying of cards so that the unauthorized duplication and copying can never be entirely negated. However, the magstrip card does continue to command a widespread use for mid security access control application. It can also be supplemented with an additional and different card technology to improve its security against unauthorized duplication.

As shown in Figure 17, in operation, magnetic stripe information is read by swipping it through a reader or by inserting it into position in a slot. Insertion type readers are not easily affected by environmental conditions and are the most suitable for external duty. They also shield the sensitive reading heads within the body of the housing, although all magstrip reader do suffer if used in onerous exposed conditions. Certain motorized insertion readers can regulate the speed in which the card passes through the reading head and therefore increases reading accuracy.

It will be understood that if the magnetic field from the card is not strong, the quality of information transfer does not depend on the strength of the magnetic properties in the strip and the cleanness of the card reading head. These cards can be colour coded so that the card is only granted access when the indicator lights on the reading head correspond in colour with that of the card. The rule is simple. If the green indicator is lit on the reader only green user cards can open the door and other colour cards are currently invalid. This is governed by time zone that switch between colours so that only certain colour cards can be swipped to gain access during normal working hours. Other colours are allowed at other hours and some colours may be authorized at all times.

It is possible to further individualize all magstrip cards by printing of photos information onto them. Although providing a photo ID card is not difficult it must be manually identified at the point of access. The reading technology is therefore complex and expensive so it tends to become a second line of access control used to confirm an authorized entrant if challenged by security personnel once inside the protected area.

Figure 17: Reader and a magnetic strips card

8.2.2.4 Optical Bar Code Cards

These are used in low security applications that generally have high turnover of staff. Visibly bar code appears as a set of parallel lines that vary in thickness to form a pattern of light and dark that is interrogated by an optical reader to form a code. These stripes represent the card information. Bar code can be printed directly onto any card, label or object and the reading equipment and software used to interrogate these are inexpensive and readily available. The code may be easily duplicated by copying so their security level is low but as they are easy to create they do have a role to play in casual entry through access controlled systems. To this end they can be quickly produced through a PC and a printer. They are also easily understood and cannot be corrupted by stray magnetic forces. The accuracy offered by the optical reader and although not often found in permanent access control system in their own right they can be used alongside other technologies to provide increased information. If a measure of increased security is needed, the bar code can be applied in a form not visible to the human eye so that special readers are needed to optically view the code.

Internationally there are a number of different bar code symbol sets and it is possible to find multiple bar codes that can be scanned as one extended bar code. The optical bar code technique is therefore of low security and although of reduced durability it is not expensive and can be used for certain temporary and causal entry system and the supplementing of other technologies to provide additional information.

As preceding Figure 18, bar code reader comes in different types to customised to individual needs. Barcode reading can be done using a laser scanner or sliding a bar code strip card on a reader.

Figure 18: 3 different types of barcode reader
(Photos extracted from www.chipsilicon.com, www.bcdata.com/omni.htm)

8.2.2.5 Smart cards

These are becoming more popular in access control system and they hold great prospect for the future. They are of credit card size but have integral micro-processing and data storage. The smart card is identified by the metallic contacts that it displays on its outer surface as these make contact with a computer terminal when the card is inserted. Essentially the smart card is a credit card sized computer with the microcomputer, battery and communication electronics and circuitry held between the battery and communications electronic and circuitry held between the outer protective PVC sheets. It has capabilities similar to a PC that extend well beyond the needs of even the most advanced and complex access control system as it can store enormous amount of personal data. It is therefore perceived as a multilevel card with the facility to hold information related to cash and credit transaction through to licenses held by person, qualification and insurance certificate and medical history.

As shown in Figure 19, smart card can be updated from a single computer source that information can be transferred to it direct from stored data. The present generations of smart cards are not as durable as most of the other types of card currently in use and they should always be stored flat and its metallic contacts must be kept clean.

We expect to see great advances in this technology but currently there are three basic types: memory only, memory with certain hard-wired logic or microcomputer. The microcomputer also contains the micro-processor, non-volatile memory (NVM), random access memory and its read only memory which holds the data on the access control operating system.

The smart card is presently used to great effect in the banking sector as it is extremely difficult to copy and is re-programmable even though its durability is low and its cost high. Nevertheless its use will surely extend further into the access control spectrum as its technology develops to make it somewhat more cost effective in security system applications.

Figure 19: Generic smart card

(Photos extracted from www.smartcardsupply.com)

8.2.2.6 Infrared cards

Sometimes called shadow cards, these cards backed in PVC but with special bar codes embedded into position. They use light sensitive infrared technology but with bar code principles for encoding. In appearance the card is opaque to natural light but once subject to infrared light the bar code casts a shadow behind the card and this is deciphered by the head of the reading equipment. The card can actually exhibit different color contrasts and shadows by employing different levels or thicknesses of PVC over the bar codes so that the light will penetrate both the PVC and bar codes to different degrees. This makes copying extremely difficult as the bar pattern is not visible to the human eye and ensures that this technique can be used in high security risk applications.

The infrared card relies on the quality of the light sensitive reader head to ensure a good performance criterion and is not affected by stray magnetic fields because of the nature of its technology. They are, however, more specialized and reasonably expensive.

8.2.2.7 Mixed Technology/Dual Technology Cards

This is a technology that combines a variety of techniques on one card and provides different functions by the employment of these different techniques. The most popular combination is magnetic stripe in conjunction with Wiegand. The user may want to reduce the number of cards that are committed to carry and the combining of the technologies on one card

addresses this need as customer requirements often ask for different data to be held; technically this may be best achieved by using different technologies. In this respect bar codes are ideal for storing information on record keeping whereas magnetic stripe is efficient at accessing debit systems and Wiegand gives a high degree of security for gaining entry to designated areas. In addition the use of custom designs and photos on cards helps identify persons.

Consideration must be given to the physical size of the card and at the present time there are two standards that have been pioneered by the banking industry.

- CR80
    - A common credit card size. Fits all swipe and insertion readers.
    - 2.125 inches high x 3.375 inches wide x 0.03 inches thick.
    - ISO form.

- CR60
    - A squarer card than the CR80. Restricted mainly to swipe readers.
    - 2.375 inches high x 3.25 inches wide x 0.03 inches thick.

As with all system management methods the authorized cardholder must have an honest approach to the electronic access control function otherwise the full system is at risk. To this end photo identification is ideal, as it always confirms that the cardholder is authentic. In the set-up and management role of the access control system there are certain procedures that can be recounted.

8.2.2.8 Non-Contact Identification Systems

In non-contact identification systems the card or token does not need to touch a reader in order for the transaction to be validated. There is therefore no wear on the card or tag since no physical contact between it and the reader is made, so the non-contact identification card has an inherently longer life than that of the swipe or insertion device. These types of systems may equally be referred to as proximity systems as the tag only needs to be in the same proximity as the reader to be recognized using radio frequency transmissions.

The readers can be held in vandal-proof locations and be hidden so they are secure in operation. The readers operate with low current consumption to the same levels as those of magnetic stripe and Wiegand card readers.

As there is no direct contact the speed of human or vehicle traffic through an access point can be increased and cards or tokens can be held in pockets or in display positions that enable hands-free access to be achieved. Doors and barriers can open without any need to insert or swipe a card through a reader, although the reading range of systems differ and with some it is still necessary to hold the card or tag close to the reader but without having to make physical contact. The terms proximity and hands-free are used for many different product lines but it is advisable only to class products as hands free when the system can read the tag without the user having to hold the tag close to the reader.
Proximity systems refer to a technique in which the tag can be read without contact being made with the reader but in practice the tag's range may be less than half a meter. Clearly these systems do not enable persons to pass through an area when both hands are occupied.

These systems may also be called radio frequency identification systems (RFIDS) and use the term transponder in preference to card or tag. These transponders are used in conjunction with a reader device that scans them for the data that they contain and this can then be processed by a computer. In practice the system has a transmitter/ receiver unit which excites the magnetic coil in the card when it is in range. This range is extended when the card also holds an onboard battery. The coil in the card then generates a magnetic pattern that represents a code within its memory chip. The transmitter receiver unit collects the magnetic pattern that it amplifies and transmits to the processor for analysis. There are essentially two types of system or tags, namely passive and active:

- Passive tags. The operating power is received from the energy generated by the reader. The tag is therefore passive in the sense that it does not generate energy, and relies on the strength of the field from the reader and transmitter/receiver control unit for the power needed to make them responsive. This is performed by the use of tuned or field powered circuits:

- Tuned circuits. Within the tag an electrical circuit resonates once it enters the radio frequency field that has been generated by the transmitter/receiver control unit and as it resonates it radiates the energy back to the reader but at a different frequency and this is its coded response

- Field powered circuit. These are more complex and tend to have a memory function. They have a power supply that is able to convert the radio frequency energy as emitted by the tag into electrical energy that is subsequently used to power the tag.

- Active tags. The tags carry their own onboard power source which is essentially a miniature battery. They are therefore active since they do of themselves provide power to the integral electronic circuits of the tag or token that contains the receive/transmit coils and memory logic PCB. The batteries become less powerful over time and need systematic replacement. These tags, however, are not governed by the strength of the reader's radio frequency field in the same way as the passive token and will generally have a range of up to 2 meters, although more specialized equipment will claim far greater distances.

Passive tags are smaller and lighter than active tags. They are less expensive and have virtually an unlimited operating life, but active tags have a greater distance reading range and can be scanned faster so are better employed if persons or traffic are attempting to pass through a controlled area simultaneously. All transponders are available in different formats that can be Read Only, Write Once Read Many, and Read/ Write:

- Read Only. These are encoded at the point of manufacture and cannot be reprogrammed.

- Write Once Read Many. These are normally also encoded at the place of manufacture but alternatively can be encoded at the location of a registered user to avoid delays with data encoding. Otherwise they are the same as Read Only.

- Read/Write. These are flexible in use and allow encoding by the manufacturer or user and can also be reprogrammed to offer new levels of data and changes to the information they

hold. This format is adopted where information is required by systems that are not interconnected and do not therefore share database information.

A further variable of the tag is the frequency at which the system operates. The system performance can be altered by a change to the size of the tag and the size and power of the reader, but the following frequencies are the most common:

- Low frequency tags operate in the range 100 to 500 kHz. They have a reading range of 10 to 200cm but a low reading speed. They are of relatively low cost.

- High frequency tags operate in the range 10 to 15MHz. They have a short reading range of 1meter maximum but have a high reading speed. They are of medium cost.

- Ultra high frequency tags operate in the range 850 to 950MHz or 2.4 to 5GHz. They have a long reading range in excess of 10meters with active tags and have a high reading speed. They are of high cost.

All these non-contact identification systems are high security but tend to be most used in the larger establishment, although they do offer rapid door operation for authorized persons and rapid barrier operation for vehicles. The hands-free concept is invaluable if the transporting of packages is a frequent event, as doors can automatically swing open to allow access.

A major consideration of these systems is the location of the reader and its operational function as it must both stimulate the token and then analyze the data that is refocused back to it. The reader or transmitter receiver must hold the power source and the antenna plus the processing electronics. These may be held as an integrated unit in one housing or they may be separately located. The antenna can be found in one of many forms to the point of being concealed and encircling the full perimeter of a door.

All these systems, however, because they use radio signaling technology, are affected if the reading equipment is in close proximity to other sources of radio frequency energy emitted by televisions, computers, printers and such. The signals are also weakened by local metallic materials, and metal door frames are a distinct hazard.

The non-contact identification system can use a multiple of codes and the tokens are manufactured and tuned to re-radiate a prescribed number of frequencies, although a greater level of accuracy is achieved if tuned circuits that operate at adjacent frequencies are not used within the same token.The passive tag can also at times be found alongside other technologies such as magnetic stripe to carry additional access data for logging purposes.

As an overview we can say that the non-contact identification system is in the main used to achieve convenience through ease of access but coupled with high security. These techniques also avoid vandalism being carried out on conventional readers or abuse of them by inconsiderate users. Radio frequency readers may also be mounted behind protected partitions made from standard building materials yet still carry out their reading function. Vehicle recognition is easily accomplished and more powerful equipment can be adopted to drive active tags that can be read over extensive distances.

8.2.2.9 Personal Characteristic Systems

Personal characteristic system is also called biometrics, as derived from the term biological data, they are used when the need for high security access authorization offsets the relatively high cost of the technology. These systems are based on the use of physiological patterns that are interpreted by a number of different techniques. They were developed in order to defeat the problem of cards, tags or tokens being shared, lost or stolen or PINs being observed.

Although personal characteristic systems do create extensive computer data and files they can enroll individuals in a matter of minutes and verify the authenticity in only a few seconds with high levels of accuracy. Complex systems can update individual templates, which hold the information, on a daily basis to take account of the ageing process. There are a significant number of personal characteristic systems in use and certain of these also incorporate a PIN for extra high security, but of course this does lead to a slower verification process. Using advanced data compression techniques certain systems can be found to offer biometric data such as fingerprint identification on cards and although this leads to easier storage of computer data the cost of reading equipment can be excessive.

Certain aspects of our physical or behavioral characteristics are unique to each individual and they form the basis of this technology There are particular advantages and disadvantages:

- Advantages. Gives automated verification that the person attempting to gain entry is authentic. No other systems can provide such verification. No additional means of entry is needed other than the unique personal trait.

- Disadvantages. Cost is high. The length of time to verify is longer than that of most other systems and levels of accuracy must be carefully calibrated.

As shown in Figure 20, the most popular biometric characteristics are: fingerprint/palm recognition, hand recognition, eye pattern identification, voice recognition, keystroke dynamics, handwriting and combination techniques.

Figure 20: Biometric characteristic system

8.2.3 Contingency

8.2.3.1 Safe opening and closing

As the barrier opens and closes, it must not cause any injuries and damages to the people and vehicle passing through it. Although barriers can be so designed to break on impact during their opening and closing cycle if they are to hit onto an obstruction. This idea may not always be suitable since some barriers must have high degree of impact resistance. Therefore, the normal method of incorporating safety is to fit a sensor at the barrier edges. These may be simple switches that automatically stop the barrier when an obstruction is sensed. Alternative,

a road loop that sense objects in the path of the moving barrier and stops its motion until the obstruction is removed.

In all cases, these safety features are best incorporated directly under the control of the local barrier rather than controlling a number of barriers and functions. This is to ensure that it does not compromise the safety measures of the local barrier.

8.2.3.2 Emergency Exit

This may be required if there is a power failure or an emergency that demands the evacuation of a site. All barriers are designed restored open position, kerbs and bollards are retracted and turnstiles become free to rotate during power failure. There are also options to provide manual overrides so that all barriers can be manually open to allow safe exiting. The barriers that are used across the range of access control system will vary enormously in terms of strength, security and means of operation. For additional security and safety we will use flashing lights, loop detector and alarm interfaces. There may be emergency power supplies and acoustic operating signal equipment.

8.3 Conclusion

There are great varieties of crash barriers and each is set up and designed specifically for its purpose. Therefore, they are best used under that specific situation. Lack of communication protocol between the barrier and checkpoint is a common crux and is critical.

While turnstiles conceptualized well to deter casual piggybacking, it is not applicable in vehicles queue where size and mobility are of concerns. Moreover, neither the vehicles nor drivers are able to push the turnstiles or automated the process safely. Nevertheless, it governed against dash through effectively.

Rising kerbs conceptualized closest to desire. It served well on any ground terrain and raised in seconds to deter dashing through vehicle. However, it is in build onto the road to provide better impact force against collision vehicles where mobility is a specification. Nevertheless,

there are many ways where the same objective - to stop a dashing vehicle is achieved and done differently. Physical gates are massive and do not serve diligently well. The opening and closing pivots around large radius on flat ground only and thus make it impractical for certain application.

Similarly, there are many types of authentication, authorization products ranging from the most sophisticated biometric system to the conventional one – barcode and magnetic strips. Each applies best at different working environment. Both accuracy and processing speed is contributing to the cost factor. High accuracy and reliability greatly dependent on quality of processors. A higher range obviously cost more and possesses analysis intelligence to establish rejection or acceptance while the lower end product can be programmed towards total rejection in ambiguous situation. While this is seems more caution than accepting it, it creates unnecessary long queue and waiting time.

Often than not, hardware limitation are considered to perform the job well, software application are always deem secondary. Subvert the fact, software limitations will hinder future expansion and capacity of data capturing is a good example of it. While authentication and authorization works hand in hand towards resilience system, its speed and accuracy of clearance is always a main priority.

9.0 Undercarriage Analysis

Undercarriage System whether manual or computerized will react to the way they are used. Users are satisfied the way these systems are initially planned for. However, workload changes as the demand grows and the current information processing system will require alteration to meet the heavier burden. System analysis is the study of the current information processing system and the design of a new improved one. This analysis should be carried out in details and concise as the main reasons for system failure is bad design. Analysis should follow a process that will develop an information processing system through a well-defined problem solving approach. It is broken down into a number of stages as explicit below. [14]

9.1 Feasibility Study

The purpose of feasibility study is to decide whether defined problem exists and if the true nature needs to be uncovered. Often, the real problem faced by users and the one stated are not the same. Three dimension of Undercarriage system that has to be considered are:

9.1.1 Technical Feasibility

Technical feasibility concludes if it is technically possible to achieve the user requirements. From the previous studies, it is understood that users are performing hard manual vehicle undercarriage screening work. The disadvantages and possible improvement were clearly explicit. In gist, it is tedious and both time and manpower consumed. The routine duty reduces vigilance and concentration. As suggested, these unvalued added tasks could be integrated with both vehicle undercarriages screening and access control where automation plays a major role. With the advance technology today, above suggested automation is possible. Vehicle Undercarriage screening can be automated with strategically placed cameras underneath passing vehicles. Access control can be enforced with permitted tokens reader and proper protocol with vehicle undercarriage system. Apart from technical feasibility, many others concerns played apart and contributes to the underlying changes. [15]

In the meantime, organization does not have existing hardware, software or resources to build on. Neither does it have the technical expertise. Nevertheless, it can be acquired. A customised hardware and software will be preferred as it could properly serve its functionality. Help supports can be acquired from the company who proposed the system. Proposed system should be considered for maximum capacity, catering future volume needs and meeting the performance. However, reliability and accuracy is a hesitation. A system could perform its purpose readily well, but would deem inappropriate if information could be misappropriate or unprotected against abuse. Similarly, protected information would be absurd if it does not provide accurate result. The following sub chapters shall elaborate its implication.

9.1.1.1 Privacy and Profiling

With the incessant improvement on information storage, it is relatively easy to store but privacy of information is compromised. Currently vehicle undercarriage images are stored in computer hard disk as digital picture file images, which are retrieved for investigation when situation warrant for. However, credibility is doubted as digital images do not safe guard against tempering. Neither was it able to detect any minor modification.

On top of information privacy issues, most individuals do not even know of all places where information about them is recorded. Even if the freedom of Information Act 1982 gives a person the right to check this information in many cases, that person cannot take advantage of the right if they do not know where the information is located. For instances, driver particulars and vehicle ownership can be established by sharing database with the relevant department. Through exchanging of informations, police eliminate possible terrorist suspects. However, abuse of system information is crucial and efforts should be taken to enforce. If not for, public trust and confidence could be tarnish.

Commercial mailing lists are consequence of existing profiling. Most people received various kind of correspondence because they have been registered on a computer-based mailing list. These customers profiling are valuable to companies' interest. Companies would send correspondence pertaining to the customer interests only. Turning profiling into our application, fast clearance of vehicle queue could be prioritized if system possesses updated guests' lists and vehicle numbers. The systems' recognition facilitates queues fast and prompt. Indirectly, it associated with profiling and the question now lies on the protecting privacy.

9.1.1.2 Data Matching and Error

People are mystified or overawed by technology. The problem is compounded by the facts that it is difficult to prove errors where computers backstage works are involved. Some people are inclined to believe that computer produced figures must be right. Undercarriage system is an extremely clever device that is unlikely to produce error, however, computers cannot guarantee that the data stored are accurate. A well-known phrase "garbage in, garbage

out (GIGO)" reminds that if an incorrect piece of data is entered, the data will not be corrected until a specific instruction is given. Further, system can also malfunction, [13] which may sequel in handicapped and stoppage of work process.

Data Matching refers to pairing or linking pieces of informations together. This piece of information correlates and tells more than truth. Searching of vehicle number plate will obtain vehicle ownership. The vehicle ownership is checked against the invited guest lists and match against police accused wanted list. In this way, raw information on mere vehicle number had unfolded the truth of accused.

Data matching is result based and does not allow check and balance over the result. A single vehicle number digit error sequel in wrong data matching. This error proliferated over stages and implicate badly.

On top of that, designer has to take contingency planning in disaster recovery planning. An important element in security system, which is also the best defense is to be prepared for various eventualities. Destruction of most all organization computing facilities can cause significant damage. Therefore, it is difficult for organization to obtain insurance for their business without showing a satisfactory disaster prevention and recovery plan for the information system. [15, pg 391]

9.1.2 Economic Feasibility

Economic factors of a system weigh heavily in the design process and engineering economy is an order for the design to enhance net value. The field of engineering economy quantifies the benefits and costs associated with engineering projects to determine if they make or save enough money to warrant their capital investments. Therefore, analyst must decide whether the cost of new system will be more or less than the benefits. Having said that, analyst has to numerate the list of advantages over disadvantages. However, intangible benefits are not measurable with cost and straightforward. Therefore, there is a need to generate detail studies.

9.1.2.1 Cost Analysis

An accurate estimate of Undercarriage Vehicle Screening System costs provides an essential part of the proper basis for management decision and control. The most obvious reasons for producing cost estimates is to assist in pricing decisions, but that is by no means the whole story. Cost estimates are usually needed for all commercial projects, including in house projects and those sold without fixed prices. Timescale planning, pre-allocation and cost control is the measurement of achievement against expected performance.

Considering on the fixed cost- not affected by changes in activity level over a feasible range of operations for the undercarriage capacity or capability available. The cost remains unchanged even though the workload might fluctuate between zero and maximum capacity. Typical fixed cost in undercarriage includes insurance and taxes on facilities, general management and administrative salaries, licence fees and interest costs on borrowed capital. Selection of undercarriage partially relies on fixed cost. Regards over the years, a higher fixed cost generally means a higher system maintenance cost with the same work output. Ingress, it would be less favour when selecting but could be neutralized as goes with low indirect cost.

A full scaled automated undercarriage system with customised software acquired cost no lesser than twenty thousand dollars. Each damaged hardware item is replaceable with cost. Benefits inclusive of lesser manpower, accurate analysis of undercarriage images. Longer working hours yet remaining its vigilance etc will definitely over ruled the cost but break-even time is a factor of consideration.

Indirect cost is the provision of facilities and services such as undercarriage training cost, system maintenance cost, system calibration, which contributes to the expenses. These costs include salaries and wages, material and other expenses but general cost cannot be allocated directly to it. Selection of undercarriage depends partially on indirect cost. A high indirect cost does constitute to second consideration thought on selection of undercarriage system. Comparatively, both indirect and direct costs have similar critical effect on system selection. Ideally, both should be low that tantamount ideal. However, in practical situation, it would never be possible. Management thus has to make hard decision based on others factors.

Vehicle Undercarriage Scanning System is affected by “Below the line cost”- This term is used as a collective name for the various allowance that are added once a total basic cost estimate has been made. These include allowances or cost escalation, exchange rate fluctuation and other contingency allowances. [19] Undercarriage system is most subjective to cost escalation. The element of project cost in terms of labour wages could rise unnoticed over the year due to inflation. Future labour cost could rise many times more than today. In additional, the prices paid for systems’ material and components are expected to rises over the years. Inadvertently, these had raised cost escalation.

Direct costs are cost which can be attributed directly to undercarriage system job. Material, components and expenses directly attributable to undercarriage system can be classed as direct. In application of undercarriage, power supply bills incurred directly on a higher cost than manual operated undercarriage. Material costs also increased due to more robust material used in the system. Replaceable but yet fragile and wear and tear components such as cameras, bulbs used in the undercarriage system are more costly. Where else, in manual undercarriage, the material costs are kept to its minimal with little or no replacement needed.

Factory cost is the total manufacturing cost of undercarriage system before addition of mark up for profits. It comprises of all direct and indirect costs for labour, materials and expenses associated with manufacturing. In general, the more supplicated the system, the higher the cost would be. However, this cost is a one time off cost and does not contributed much considering factors. Neither does it have adverse

9.1.3 Social Feasibility

Social feasibility refers to acceptance of technology or change of technology in work place. It also involves attitudes and capabilities of existing staff to the new system, particularly if the previous one was a manual one. [14]

9.1.3.1 Job Change

Job change in undercarriage inspection does not mean that people resign from one job and are employed in another, but rather the nature of their present job changes. They extend the range of services offered. There is an endless variety of situation where individuals have been required to adapt their skills and modify their work practices to improve their output. For instances, officers have been using manual mirror inspection looking out for suspicious hideout under the vehicle undercarriage. Job change refers to the way it is done. With automation, officers can perform others task while the mundane work condition are left the systems. In some ways users see their old job as being partly lost although in most cases it is the worst parts of their job, which have been gone.

Few people like rapid changes. However, the experience can be made better or worse depending on how the change can be initated. Often the alienation feeling can be avoided if employers and industry leaders took care with its introduction. Changes involving new technology will cause less disruption and stress if the people affected are involved in the decision making process. It is important that the people are told about the reasons for changes and its benefits. When possible, user should be involved in the design or selection of systems. The failure to recognize the need for this involvement has had extremely negative effects on the lives of individuals and ultimately affected the quality of their work. Similarly, ground officer who are the end user of the system have the most valuable views. Their suggestions and views should be consolidated and discuss for possible areas of improvement and potential features.

9.1.3.2 Importance of Training

One of the most common problems arising from the introduction of new technology has been the failure of employers to devote time and money to training. In many instances, companies spend huge amount of money on equipments, expecting instant result and improved efficiency from untrained staff. It is critical that staffs are trained before using the new equipment. It can be a very alienating experience if staffs are force to use without help. Substantial funds should be allocated to training as the same time as funds allocated to

equipment. Of course, employee must be willingly to retrain when their job change and no matter how sensitively handled, it is likely to cause some stress.

9.1.3.3 Psychological Effects of Change

The way people respond to technology is affected by their attitude to the technology. If they are threatened by it, they act negatively. If they see new technology as providing new challenges and opportunities, they respond positively. It is common for technology to cause emotional responses. Given the way in which human beings attach emotional commitments to people and things. It is reasonable to expect a wide range of response to technology

Age is another factor which influences people reception and reactions to computers. Younger people respond far more readily than older people. Older people are more conservative and less trusting of new ways of doing things. Many older people see some comfort in the fact that they will be retired before their job requires them to use a computer. For some, technology have pushed them into early retirement or pressured them to develop new skills towards the end of their career.

9.2 Detailed Investigation

Investigation involved thorough study of the problem, which includes questionnaires and interviews with users and management. Interviews provides effective basic information gathering and as a checking technique. Interviews may be conducted during any stage of the project as the need arises to gather more information about the system. At the same time, investigation will document present system's procedure and observation. The documented information is used to revise possible improvement.

System Development Life Cycle (SDLC) will be adopted. It is a logical approach to large scaled system development. SDLC is an extremely comprehensive ensuring that all stage of the development of a system are thought about, planned, monitored and completed. The full SDLC remains most appropriate to situation where there are predictable information system

requirements. SDLC is a highly project manageable as the stage can be clearly identified, scheduled, monitored and controlled.

9.2.1 Present Situation

Shortage of Manpower

Currently, one checkpoint comprises of eight to ten officers. In major events where crowds size are expected to be twenty thousands and above, four to six checkpoints are set up to ensure smooth clearance of vehicle screening. In such situation, fifty to sixty officers are deployed a day. More officers will be deployed for event lasting a week or more. In view, policing officers doubled their work load causing uneven work life balance Each officer is assigned with specify routine work scope as specify in chapter 7. Chapter 7 elucidates deployment strategies and effects. Many of the static tasks could be replaced with technologies. Technologies ease boredom task but yet remains high efficiency without error and rest.

Non conducive working environment

To allay boredom and tiredness, appointed tasks are rotated at stipulated time frame. For instances, an hour of traffic controlled duty is changed with vehicle screening duty. Task rotation continues till the end of shift duty. Despite the effort, tiredness continues and creates ineffective work output. Officers are rotated to new tasks, which are different from previous work scope. Although, they would learn as they work, mistakes are inevitable. However, it creates possible terrorist penetration during the period of learning. Officers on duty have to stand throughout their duties. There were no seats for rests even during off peak period. Prolong standing cause great tiredness and in turn reduces vigilance. Standing creates stress at the knee joint. Excessive impede stress cause uncomforted to pain.

In certain deployment, checkpoints are not sheltered. Officers are obligated to work under sun and rain. Thus it creates extreme work conditions. Working in Singapore climate is hot

and stuffy. Officers felt sweaty and warm, especially in their uniform. However, climate is something beyond the human control.

On top of that, officers on duty are exposed to large quantities of carbon dioxide and carbon monoxide generated from vehicles 'exhaust pipe. As officers inhaled unhealthy exhaust in long period of working hours, it will complicate health condition. Officers on duty at the queue area are to hand signal and guide drivers to the correct available checkpoints. Although on duty officers wear reflective vest to appear vivid from the dim working place, they are still in risk from being knock down by vehicle. Sadly, there is no safe guard against our vulnerable officers.

Long Congested Queue

Vehicle owners who choose to self-drive are obligated to have their vehicle checked. During peak hours, vehicles queue are long and waiting time are protracted. The long waiting time results from insufficient checkpoints and officers on duty. An average screening with four officers to a vehicle takes a full 2 minutes to complete a thorough screening. Long congested queue perturbed drivers and arises their complaints.

With the latest available checkpoints, officers' hand signal to the queue-waiting driver to proceed. Hand signals could be very misleading. From personal experience, it had delivered the wrong messages across, resulting in unpleasant experiences. Therefore, much could be done to eliminate this problem.

Unsuitable Crash Obstacle

As vehicles approaches checkpoint, they were forced to drive at very slow speed by maneuvering through "S" shape route. With tight and small "S" drive route, it is impossible for driver to speed and dash through the checkpoints. This had effectively confined vehicles to slow driving speed. Slow speed dictates lesser collision impact. In situation of terrorist vehicle contraband with explosives, the slow speed collision may not ignite explosion and would tremendously reduces possible damages and casualties. Currently light weighted plastic obstacles are used as barrier to guide maneuvering vehicles. Nevertheless, light

weighted plastic obstacles failed to serve the basic function; stopped vehicle from crashing through the checkpoints.

The other types of movable obstacles used are police vehicle (land rover). Police vehicle has the flexibilities to tighten or loosen the "S" route in accordance to the size of vehicle. Vehicles such as coaches could be adjusted accordingly and closed back upon completion. However, police vehicle should not be used as crash obstacle. High cost would be incurred if accidents took place. Besides, flammable vehicle fuel may be resulted in uncontrollable fire.

Poor Defense Setup

Apart from the "S" route, there are no other defenses against terrorist attack. A terrorist vehicle filled with explosive dashing in high speed will definitely succeed passing through the checkpoints. This is undesired as escaped vehicle with explosive will posed exclusive threats to the protected events and all securing efforts will be drained. Although checkpoints are not terrorist attack targets, it should be protected against blast. However, today checkpoints are not protected against blast. If tragedy were to happen, it would cause massive casualties and extensive damages.

Not Thorough Check

As mentioned earlier, degree of concise check depends on many factors. One of those is human factor. Human are very complicated species where performances are influenced by emotion and mental. When human feels bother, they are not able to remain concentrate and focus. Thus 100% human dependent checks possibility failed. It highly risks the success chance of penetration. Nevertheless, there are factors that does not concerns human. Blind spots could be one, which falls under limitation. Trolley
undercarriage checking devices allows officer to check slightly after the breath of the vehicle wheel. Each side covers the same area and thus left some in the mid center unviewed. These areas are known as blind spots. Blind spots are also known as loop holes and should avoid from terrorist knowledge. Awared terrorist would make use of blind spots to hide from detection.

In off peak period, supervisors will arranged more officers to go on rest break so as to prepare for latter peak period. On duty officers have to juggle more than his post duty and result in diversify of attention. When diversification happens, quality of work deteriorated. Deteriorated work risk the success rate of penetration, causing disaster.

Inconvenience to Visitors

While 4 others officers are performing the undercarriage checking, the driver and passengers particulars will be recorded down manually on a piece of paper. To facilitate fast recording, guests are prompted to give their national identification card. For those guests who did not bring, they will iterate the details to certify their particulars. Much inconveniences and time are lost. This information is collated, filed and used for investigation only when situation warrant for. Searching for guests' records are tedious and ineffective. Although events may be meant for invited guests only, there are no check and balance master list. Thus, there are no strict controls against those who poster as invited.

9.2.2 Workflow of Manual Undercarriage

It is important that the undercarriage inspection workflow is understood before building on and replacing with a new system. Otherwise, it would be building a computer system that do not match business needs and worst still do not interact with other system. There were some instances, management spends millions of dollars upgrading the system, and effortless the real problem was wrongly understood. The new system was not able to optimize its capability neither was the initial problem resolve.

An initial step is to organize and analyze all the information gathered. Without a clear understanding of the preset system, it will not be possible to decide where the problem lies. Without this information, the new system will be no better than the old one. Nevertheless, new system should not be changed too drastically from the current practice unless the current is not workable or loophole practices needs to be tidy up. Drastic change would mean a new working procedure and user have to learn from onset. It takes more time and cost to train to its proficiency.

As shown in Figure 21, Workflows are marked systematically in rectangles shapes. Oval shapes dictate the header of each process or continual from the next pages. A diamond shape dictates a decision stage and will be branched into either one of the two conditions. After the condition decision, it flows along the specific branch workflow. Workflow allows bystander to have a clear understanding of the work sequence. It distinctively shows incorrect work procedure and provides opportunity for improvement.

When the present system has been analyzed and documented, the analyst must liased with the user to identify what is required in the new system. From the understanding gained from the study of the old system, all analysts will be able to imposed new and required function to improved the current system. Proceeding shows the flow chart of current work process.

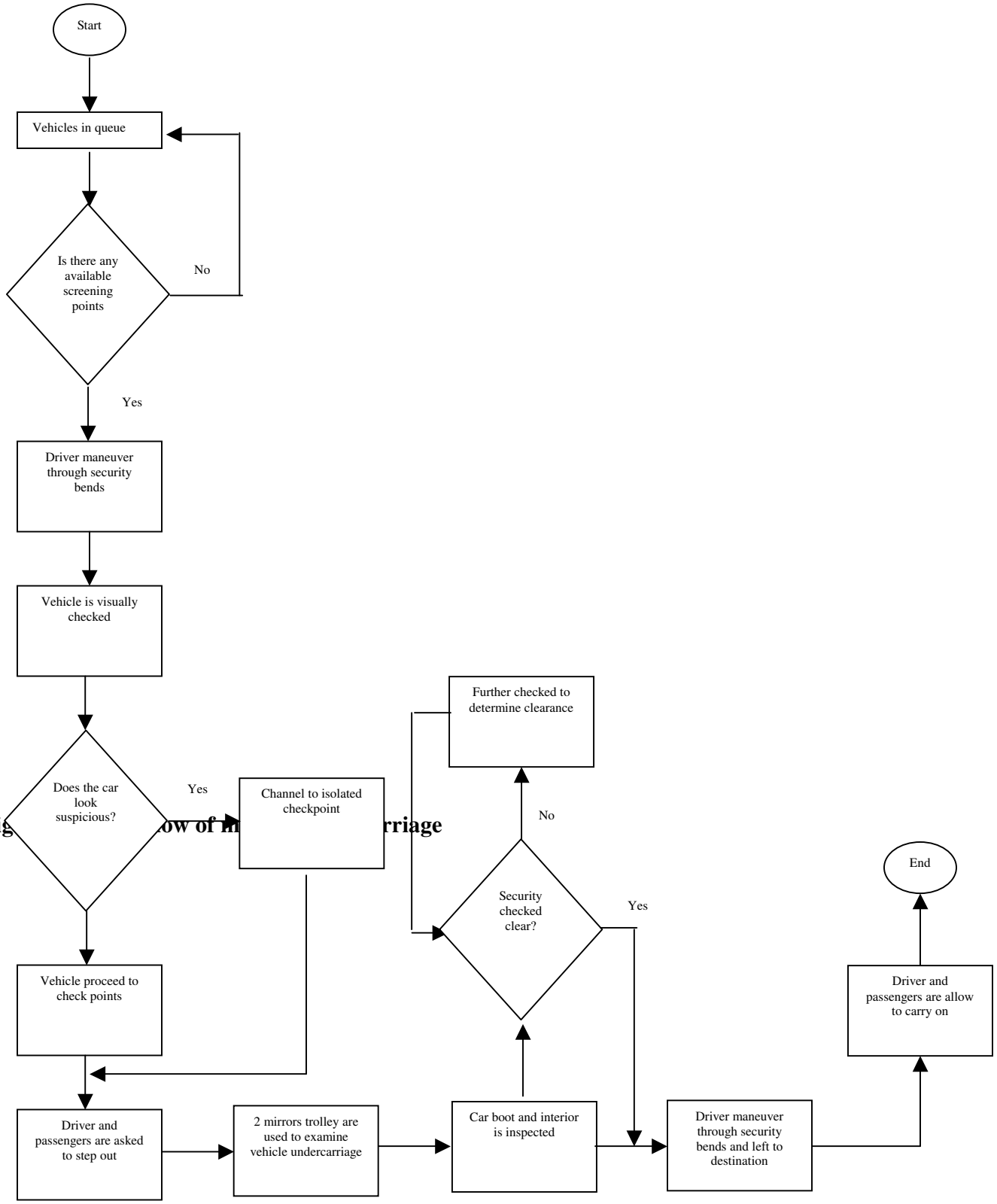

Fig ow of i rriage

9.2.3 Data Collection on Agreement

After obtaining the authorization, interaction with the management and user was conducted to understand the problem and opportunity, project scope, constraints and project benefits. If the system request involves a new information system or a substantial change in an existing system, a detail studies has to be conducted. For a start, 100-management officer and 200 users are selected for this data collection. Preceding table 3 shows result of surveys and questionnaires conducted with management and user level.

Factors	Percentage	Remarks
Does mgt support?	77% supported, 33% not supported	Reliability is a concerns
Does user support?	90% supported, 10% not supported	
Is the current method well liked and effectively used	85% Disagreed 10% Agreed, 5% NA	
Do user sees the need for system improvement	70% Agreed, 20% Disagreed, 10% NA	
New system result in a workforce reduction	60% Agreed, 23% Disagreed, 17% NA	
Will customer experience adverse effect in any way, temporarily or permanent?	60% Disagreed, 26% agreed, 14% NA	

Table 3: Data collection on agreement

The table is further broken down into vital information as shown in Figure 22 and 23 acceptability of Process Change and a need for method changed

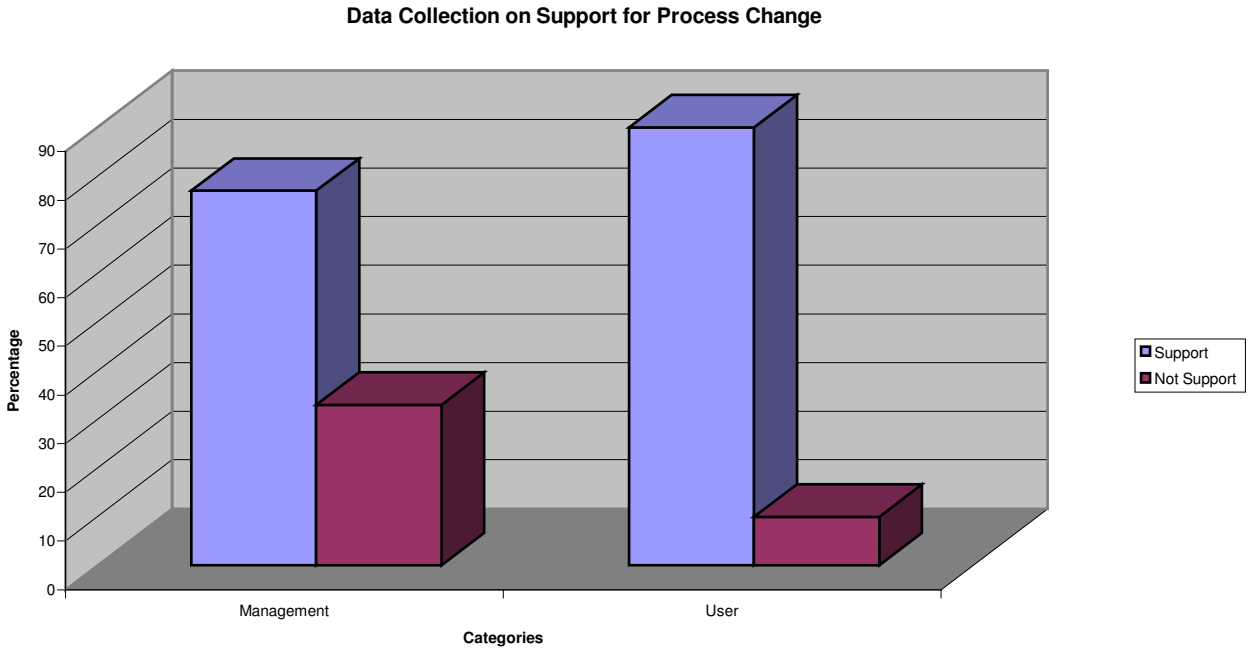

Figure 22: Data collection on support for process change

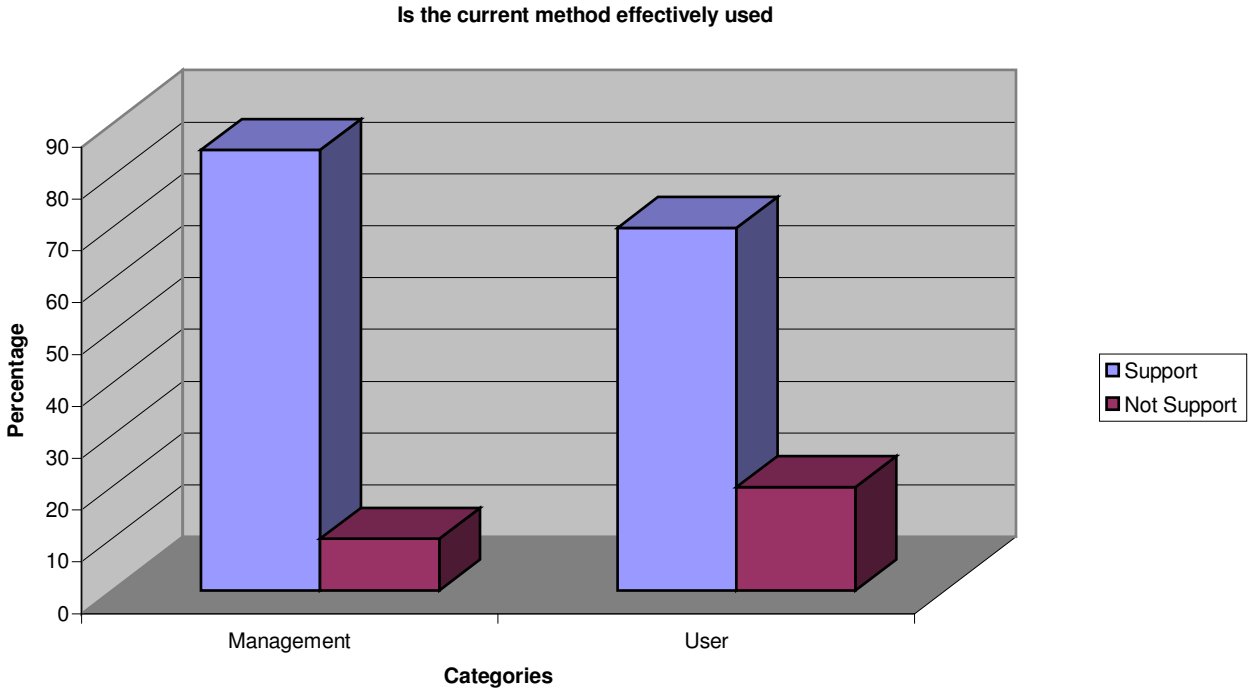

Figure 23: Data collection on evaluation of current inspection method

From each of the questionnaire and surveys above, the weightage is more than 50% average. It is obvious that both management and user are favorable to change the current undercarriage inspection. From this surveys result, amount of changes is unknown. In new system planning or designing, there is a need to understand how modifications will affect operations and other information system, even when the request involves relatively minor changes or enhancement.

9.2.4 Data Collection on Process Inspection

Analyst went on ground deployment to study the number of incoming vehicles to inspection point during peak and non-peak hour for different types of deployment. The findings were multiple with a safety factor of 2 to cater for unpredictable scenario. Finding revealed that during peak hour, there is an average of 80 vehicles per hour and 30 vehicles per hour during non-peak hour. This data will be used latter in chapter to derive the equation.

In order to obtain the average time taken for inspection, analysts simulate the process. Users were tasked to perform the inspection as stated at the above workflow over many cycles and the average time taken was recorded. Although time is objectively important, analyst felt that the quality of check was also important. They concealed dubious boxes simulating as bombs in various area of vehicle undercarriage, randomly in vehicles. The users were not informed of the concealment during the simulation process. Results shows that 10 out of the 15 vehicles concealed with bombs were detected. 5 vehicles were left undetected. From the simulation, analyst felt that the 5 vehicles left undetected were too many and this lapse should be considered into during the system design stage. From the simulation report and data collection, 4 out of the 5 concealed vehicles were left undetected after an hour where fatigue took place.

Analyst repeated the simulation process on new user. The result greatly differs between experience and new user. Obviously, new users have more uncertainty and took longer time for a similar task. The numbers of concealed vehicles' detection are comparable lower as shown in table 4. Similarly, analyst felt that the lapses could be considered and improved during the design stage.

Categories of user	No of bombs concealed	No of bombs detected	Average Time taken	Remarks
Experienced	15	10	7min	4 were not detected during fatigue
New	15	8	10min	6 were not detected during fatigue

Table 4: Time taken and no of bombs detection

Time taken in Seconds For Experienced User

No of Test	Vehicle Waiting in Queue	Driver maneuver security bends	Vehicle visually checked	Vehicle to check points	Driver and passengers step out	Examine vehicle undercarriage	Maneuver through security bends and left to destination	Total (sec)	Total (min)
1	180	10	5	4	60	188	10	457	8
2	120	22	4	6	50	200	14	416	7
3	150	8	6	6	30	211	9	457	8
4	188	8	4	5	45	198	9	443	7
5	176	7	5	7	44	197	7	470	8
6	181	10	6	5	49	211	8	439	7
7	140	11	5	6	50	216	11	439	7
8	155	9	3	6	51	188	9	421	7
9	158	10	7	6	53	218	9	461	8
10	187	12	7	6	59	200	12	479	8
11	167	9	7	7	60	221	8	477	8
12	183	14	6	10	56	200	8	411	7
13	177	9	5	6	6	199	9	446	7
14	169	7	5	7	49	198	11	446	7
15	145	8	5	6	56	200	8	428	7
Average Timing									
	165	10	5	6	48	203	9	446	7

Table 5: Data collection on time taken for experience user

Time taken in Seconds for New User

No of Test	Vehicle Waiting in Queue	Driver maneuver security bends	Vehicle visually checked	Vehicle to check points	Driver and passengers step out	Examine vehicle undercarriage	Maneuver through security bends and left to destination	Total (sec)	Total (min)
1	180	10	8	4	60	380	10	652	11
2	120	22	10	6	50	350	14	572	10
3	150	8	11	6	30	330	9	605	10
4	188	8	11	5	45	339	9	603	10
5	176	7	13	7	44	349	7	561	9
6	181	10	9	5	49	299	8	545	9
7	140	11	9	6	50	318	11	545	9
8	155	9	10	6	51	389	9	629	10
9	158	10	11	6	53	378	9	625	10
10	187	12	15	6	59	368	12	654	11
11	167	9	14	7	60	389	8	633	11
12	183	14	13	10	56	349	8	583	10
13	177	9	9	6	6	367	9	641	11
14	169	7	10	7	49	388	11	641	11
15	145	8	10	6	56	380	8	613	10
Average Timing									
	165	10	11	6	48	358	9	607	10

Table 6: Data collection on time taken for new user

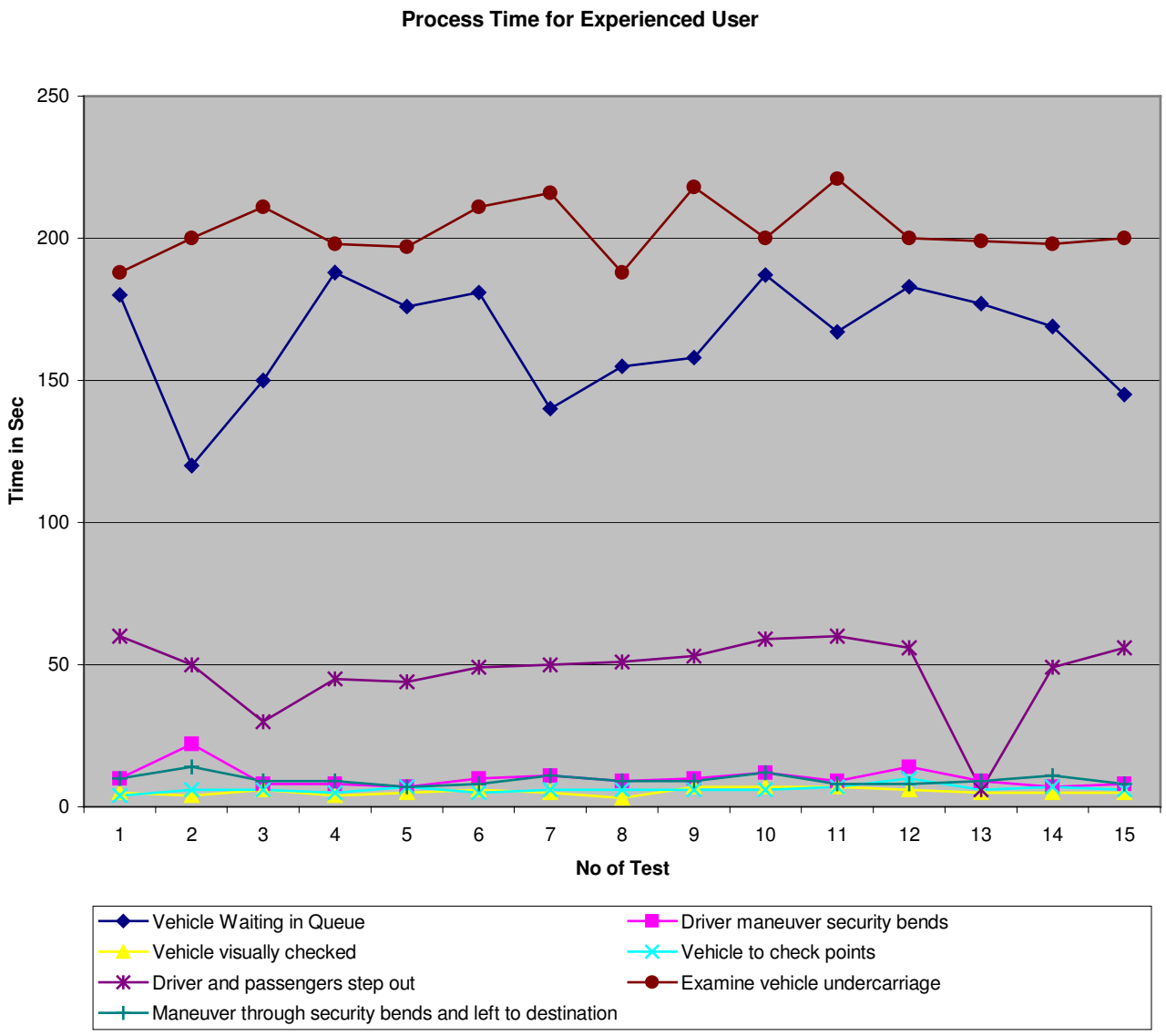

Figure 24: Process time for experienced user

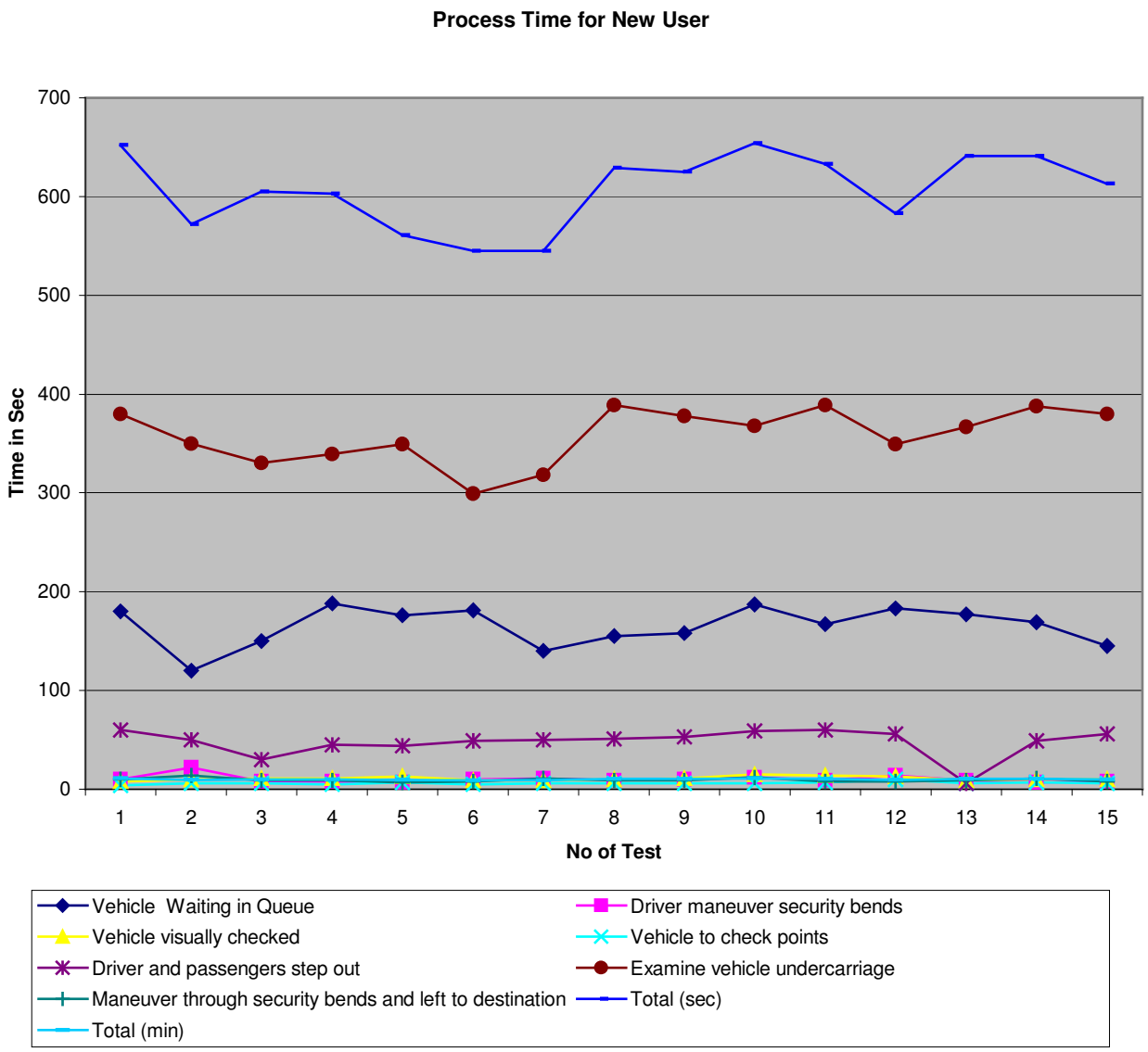

Figure 25: Process time for new user

From both the experienced and new user process time graph, it is analyzed that examination of vehicle undercarriage and vehicle waiting in queue constitute the longest time taken. Analyst feels that through system design and queue management, root cause problem could be solved.

9.2.5 Queue Studies

The study of waiting lines are known as queuing theory. It is one of the oldest and most widely used management science technique. Waiting lines are an everyday occurrence, undercarriage check points are of no exceptional. Vehicles on queue for their undercarriage to be examine prior entering to their destination Most waiting line problem are centred about the question of finding the ideal level of services that should be provided. When security agents have control, its objective is usually to find a happy medium between two extremes. On the other hand, they cannot retain large staff to provide many service facilities. Ideally, excellent customer services equate less than two customers in a queue. Customers are kept happy with the quick response and short waiting time. However, this can be expensive. The other extreme is to have the maximum possible number of checkout lines open. This keep the service cost up.

Most recognise the trade off between the cost of providing good service and cost of customer waiting time. Thus one mean of evaluating service facilities is to look at total expected cost. The total expected cost is the sum of expected service cost plus waiting costs. As services improve in speed, the cost of time waiting decreases. However, the service cost increases. There are three operating characteristics of a queuing system is 1) the arrival or input to the system. 2) queue or waiting line itself 3) the service facility.

9.2.5.1 Arrival and Service Time Characteristics

The input source that generates vehicle arrival has three major characteristics that are important to consider. The size of the calling population, the pattern of arrivals at the queuing system and the behaviour of the arrival.

Sizes of the calling population are considered to be either unlimited or limited. When the number of vehicle arrivals on hand at any given moment is just a small portion of potential arrivals, the calling population is considered unlimited. Most queuing models assumed such as an infinite calling population. Pattern of arrival refers to vehicles either arrive according to some known schedule or arrived randomly. Arrival are considered random when they are

independent of one another and their occurrence cannot be predicted exactly. In our discussion, the number of vehicle arrival per unit of time can be estimated by a probability distribution known as Poisson distribution.

$$P(X)= \frac{e^{-\lambda x}}{X!}$$

P(X) = Probability of X arrivals

X = Number of arrival per unit of time

λ = Average arrival rate

e = 2.7183

In our queuing analysis, we assume that an arriving vehicle waited until they are served and do not switch between lines. We omit the possibilities of balking; refuse to join the waiting line because of too long to suit their interest or needs. Renege; refers to customer renege; refers to customers who enters the queue but then become impatient and leave without completing their transaction. Service patterns are like arrival patterns in vehicle could be either constant or random. If service time is constant, it takes the same amount of time to take care of each customer

9.2.5.2 Single Phase Vs Multiphase System

As shown in Figure 26, a single channel queuing system is typified with one server and a single queue. Vehicle entered and exit from the same system. This model of queuing system is applicable and work well at short server time or the server process step could not be broken down into different server. The current undercarriage inspection uses this queue model and constitutes an average of 7 minutes for experience user and 10 minutes for new user, however queue are managed in a systematical manner.

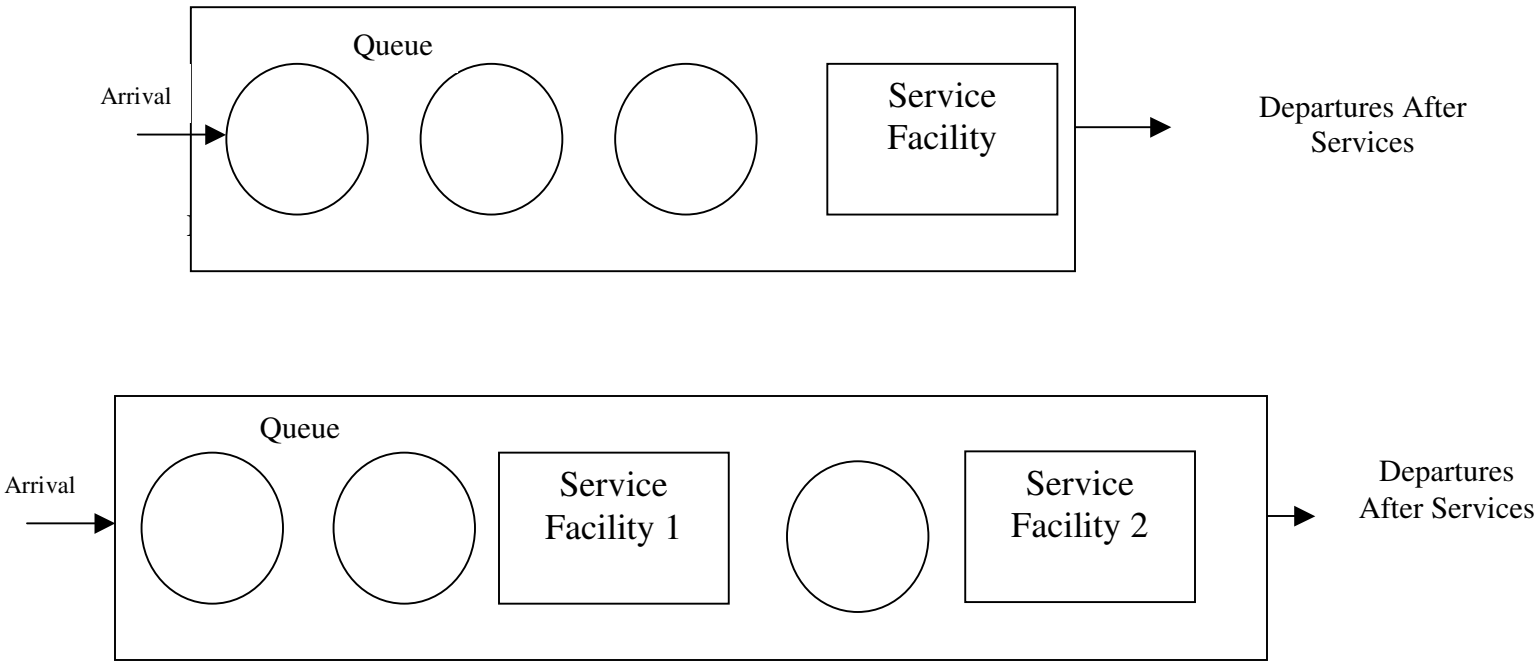

Figure 27: Single channel, multiphase system

While a single channel and single phase system does not expedite queue-waiting time, a single channel, multiphase system as shown in Figure 27, arises to adopt the lapses. While a single channel, single-phase system has long server process time, it is separated fairly into 2 or more server. Optimistically, each server takes the same amount of time and the queue waiting time is drastically reduced. Undercarriage inspection system deployed under this model has the added advantages of preventing dash through situation, comparable with single channel, single phase system. At all point of time, vehicles ahead of the first sever act as deterrence.

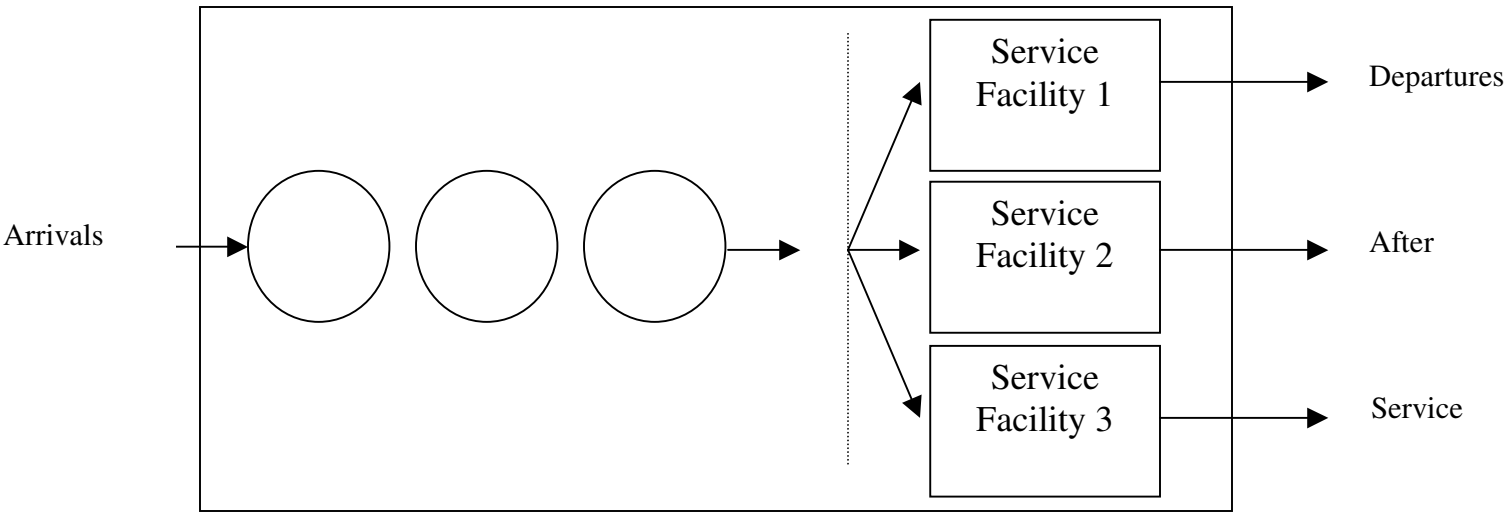

Figure 28: Multi-channel, single- phase system

From Figure 28, multi-channel single-phase system that ensures speedy clearance of the queue, but comparatively, the queue could be longer. Most banks adopted this queue model, where as many required server could be repeated in a single queue. No doubt server time would be longer, it is a one-stop service server and reduces much customer inconveniences. While queue-waiting time are consciously monitored, the server are left with no deterrence and does not reduces the chance of dash through. The advantage of deploying this queue model in undercarriage vehicle scanning system is that integrated system are in placed in each sever. This could reduce much inconvenience caused to both customer and system hardware assembly. If there were many servers, stretching vertically as show in the above diagram, it would generate a blind spot for the vehicle in queue. When this happen, there would not be a fair queue distribution of sever workload. Nevertheless, it could be improve with the sever position skew from the queue.

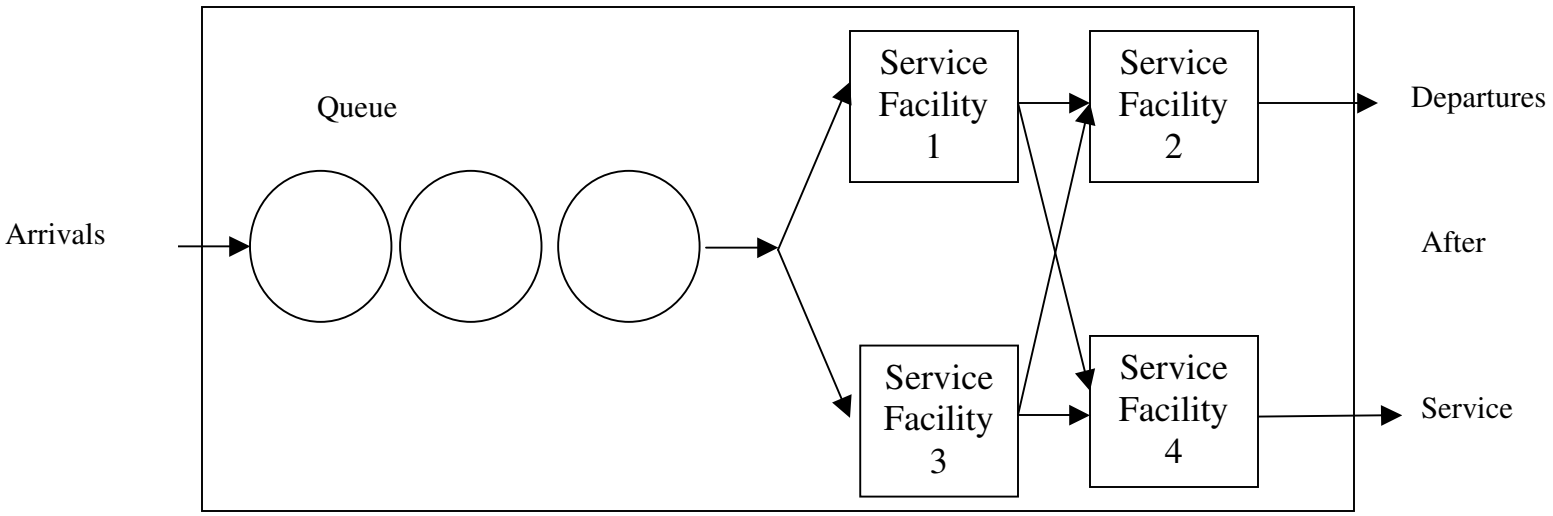

Figure 29: Multi channel, multiphase system

As shown in Figure 29, a multi channel, multiphase system clears queue fast and timely. Sever workload are broken down into two or more where vehicle proceed to the next after each the first server. In order to further reduce the process time, this model allows server 1 to cross over to sever 4 or server 3 to server 2. In this way, much time is saved and waiting time after each severs is reduced. However, it caused great confusion and possible of misunderstanding or accidents among drivers. Nevertheless, it could be countered with traffic controlled or directional instructions to the drivers.

9.2.5.3 Queuing Equations for single channel, single phase model

In the single channel, single-phase model considered here is one of the most widely used and simplest queuing models. During the time data collection on process inspection, chapter 8.2.4, it was determined that examination of vehicle undercarriage and vehicle waiting in queue constitute the longest time taken. Therefore, mean μ and variation λ was closely defined to the studies observation.

μ- 40 cars serviced per hour,

λ - 50 cars arriving per hour

M- 8 no of channel left open

It assumes that seven conditions exists

- Arrival are served on a first in, first out basis
- Every arrival waits to be served regardless of the length of the time, there is no balking and reneging.
- Arrival are independent of preceding arrival, but the average number of arrivals (the arrival rate) does not change over time
- Arrival are described by Poisson probability distribution and come from an infinite or very large population
- Service times vary from one customer to the next and are dependent of one another, but their average rate is known.
- Service times occur according to the negative probability distribution.
- The average service rate is greater than the average arrival rate.
- λ = mean number of arrival per time period
- μ = mean number of people or items served per time period

- The average number of vehicles or units in the system, L that is the number of in line plus the number being served. A negative denotes outstanding number of customer yet to be served.

$$L = \frac{\lambda}{\mu-\lambda}$$

$$= \frac{50}{40-50}$$

$$= -5$$

- The average time a vehicles spends in the system, W is the time spent in line plus the time spent being served:

$$W = \frac{1}{\mu-\lambda}$$

$$= \frac{1}{40-50}$$

= 0.1 hour

= 10mins

- The average number of vehicles in the queue, Lq

$$Lq = \frac{\lambda^2}{\mu(\mu-\lambda)}$$

$$= \frac{50^2}{40\ (40-50)}$$

$$= \frac{2500}{-400}$$

= 6.25 vehicles

- The average time a customer spends waiting in the queue, Wq

$$Wq = \frac{\lambda}{\mu(\mu-\lambda)}$$

$$= \frac{50}{40\ (40-50)}$$

= -0.125 hrs

= -7.5 min

- The utilization factor for the system, p that is the probability that the service facility is being used:

$$P_0 = \frac{1-\lambda}{\mu}$$

$$= \frac{1-40}{40}$$

= -0.975

= 97.5% utilization

9.2.5.4 Queuing Equations for multi channel, multi phase model

- Probability of 0 vehicle in the queue

$$Po = \frac{1}{[\sum 1/n! (\lambda/\mu)^2] + 1/M! (\lambda/\mu)^M \frac{M\mu}{M\mu-\lambda}}$$

$$= \frac{1}{[[\sum 1/7! (50/40^2] + 1/8! (-50/40)^8 \frac{8*40}{(8*40)-50}}$$

$$= 891.9$$

- Average number of customers or units in the system, where M equal the number of channels open:

$$L = \frac{\lambda\mu(\lambda/\mu)^M}{(M-1)! (M\mu-\lambda)^2} P_o + \frac{\lambda}{\mu}$$

$$= \frac{50*40(50/40)^8}{(8-1)! (8*40- 50)^2} 891.9 + \frac{50}{40}$$

$$= 1.28$$

- Average time a unit spends in the waiting line or being serviced (namely in the system):

$$W = \frac{\mu(\lambda/\mu)^M}{(M-1)! (M\mu-\lambda)^2} P_o + \frac{1}{\mu} = \frac{L}{\lambda}$$

$$= \frac{40(50/40)^8}{(8-1)! (8*40- 50)^2} *891.9 + \frac{1}{40}$$

= 0.0256hrs

= 1.54mins

- Average number of vehicle in line waiting for inspection

$$Lq = L - \frac{\lambda}{\mu}$$

$$= 1.28 - \frac{50}{40}$$

$$= 0.03$$

- Average time a vehicle spends in the queue waiting for service

$$Wq = W - \frac{1}{\mu} = \frac{L_q}{\lambda}$$

$$= 1.54 - \frac{1}{40}$$

$$= 1.515\text{mins}$$

From the above tabulated calculation, it was determined that multi channel with multi phase model would be the most preferred model of queue. During the design stage, system would be designed to suits this model. Although it takes more cost and efforts to set up multi phases, it is obvious that the outstanding number of vehicles in queue greatly reduced from 5 to 1. The time taken to for a vehicle to wait in the queue for inspection reduced from 10mins to 1.515mins. This was a tremendously improvement and greatly projected the benefits of multi phase channels.

9.2.6 Problem and Opportunity

The same groups of managements and users contributed their views on the problem faced and problem opportunity. These views were consolidated as we discuss and priorities according to the urgency as shown in Table 4. Ideas that are too sophisticated to implement are kept aside for phases review. Analyst had been cautious on how the management and user are interviewed. In most of the circumstances, users provide subtle problem. The main root problem should be make clear and enumerated.

Priority	Problem	Opportunity	Remarks
1	Long vehicle queue during peak hours	To increase the number of checkpoints yet maintaining the same no. Of officer	
2	Additional manpower deployed to control traffic movement	To automate and in build intelligence without officer required to perform static duty	
3	Manual undercarriage task	Undercarriage is automatically checked prior entering secondary check	
4	Undercarriage blink spots are not captured	Flexible cameras lens to allow check on suspicious area	
5	No defense against terrorist	To detain the speeding	

	attack	vehicle bomb at primary clearance area	
6	No deterrence against dash through vehicle situation	Automated erect of crash barrier upon detecting speeding vehicle	
7	No master check list against invited guest	To integrate access control as a system	

Table 7: Data collection on problem and opportunity

9.2.7 Scope and Constraints

Output

- The system is able to generate images of the vehicle undercarriage
- There is a hydraulic operated ramp which prevents dash through incidents
- Minimum manpower is needed to operate this system effectively.
- Display signs board direct drivers to available undercarriage screening system.
- Able to detect and activate dash through ramp

Input

- Sensors will queue the cars in an orderly manner
- System token recognizes invited guests details and attendance
- Barrier sensors measure speed of approaching vehicle
- Error will be prompted to control room
- Cameras to monitor situation

Process

- The process time is shorten and increase productivity
- Major process remain unchanged

Performance

- Intelligence to tell driver which check point is empty
- Barrier erected when vehicle speed is too fast
- Barrier reaction can be control be user
- Undercarriage is automatically screened for bombs
- Access control recognizes guests and vehicles
- Able to detect roof top of coaches or buses

Control

- User can over right waiting time and control each barrier activation
- User can over right all others functions in system especially when VVIP cars
- User can manual contrast the vehicle images to enhanced viewing.

9.2.8 Fish bone Diagram

Often a change in one system has unexpected effect in another system. Although some possible salient causes are spotted in observation studies, Fish bone diagram, Figure 30 emphasizing on Man, Material, Method, and Environment are drawn to analysis and confirm the root cause.

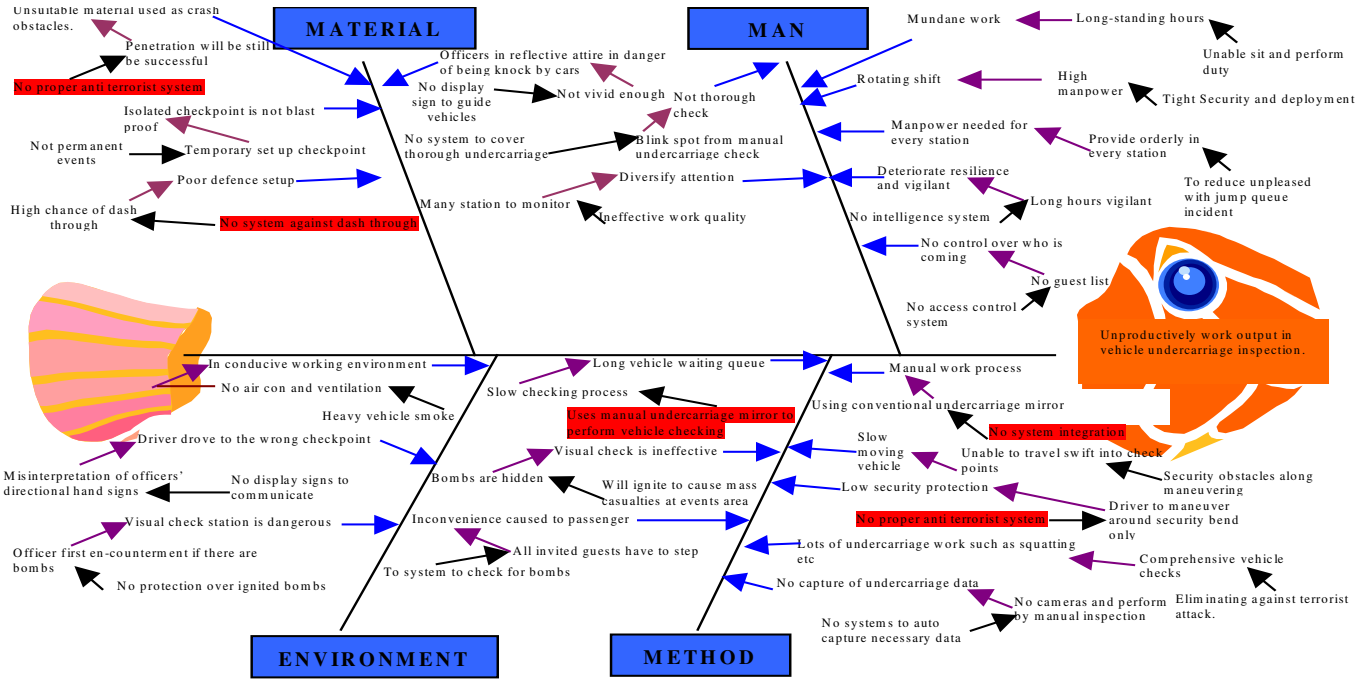

Figure 30: Fish bone diagram

From the above fishbone diagram, it is obvious that no system to deter terrorist attack and data collection is listed as the most vital root cause of today's high manpower, unproductive work quality. Interviewing with the users and management personnel affirmed the accuracy of this fishbone diagram. Nevertheless, each bone was analyzed using cause and effect diagram, as shown in table 8 to further affirm the identified root cause in fishbone diagram.

Causes	Valid	Under Control	Main Cause
Material			
No proper anti terrorist system	Y	Y	Y
Not permanent events	Y	N	Y
No system against dash through	Y	Y	Y
Not vivid enough	Y	Y	N
Man			
No system to cover thorough undercarriage	Y	Y	Y
No display sign to guide vehicles	Y	Y	N

Ineffective work quality	N	N	N
Unable sit and perform duty	N	Y	Y
Tight Security and deployment	Y	Y	Y
To reduce unpleased with jump queue incident	N	Y	N
No access control system	Y	Y	Y
No intelligence system	Y	Y	N
Method			
Uses manual undercarriage mirror to perform vehicle checking	N	Y	N
Will ignite to cause mass casualties at events area	Y	N	Y
To system to check for bombs	N	Y	N
No system integration	N	Y	N
Security obstacles along maneuvering	Y	Y	Y
No proper anti terrorist system	Y	N	N
Eliminating against terrorist attack.	Y	Y	N
No systems to auto capture necessary data	Y	Y	N
Environment			
Heavy vehicle smoke	N	Y	Y
No display signs to communicate	Y	N	N
No protection over ignited bombs	N	Y	N
Uses manual undercarriage mirror to perform vehicle checking	Y	Y	Y
Will ignite to cause mass casualties at events area	Y	Y	N

Table 8: Cause and effect diagram

9.2.9 Projects Benefits

Only a few projects would score high in all areas. Some proposed systems might not reduce costs but will provide important new features. Other systems might reduce operating costs substantially but require the purchase or lease of additional hardware. Some systems might be very desirable but require several years of development before producing significant benefits.

Whenever possible, a proposed project should be evaluate based on tangible costs and benefits that represent actual dollar value. Often evaluation involves intangible costs or benefits as described in the section on economic feasibility. Intangible benefits often influence decisions and priorities and must be considered carefully.

10.0 Design of Access Control

10.1 Design 1

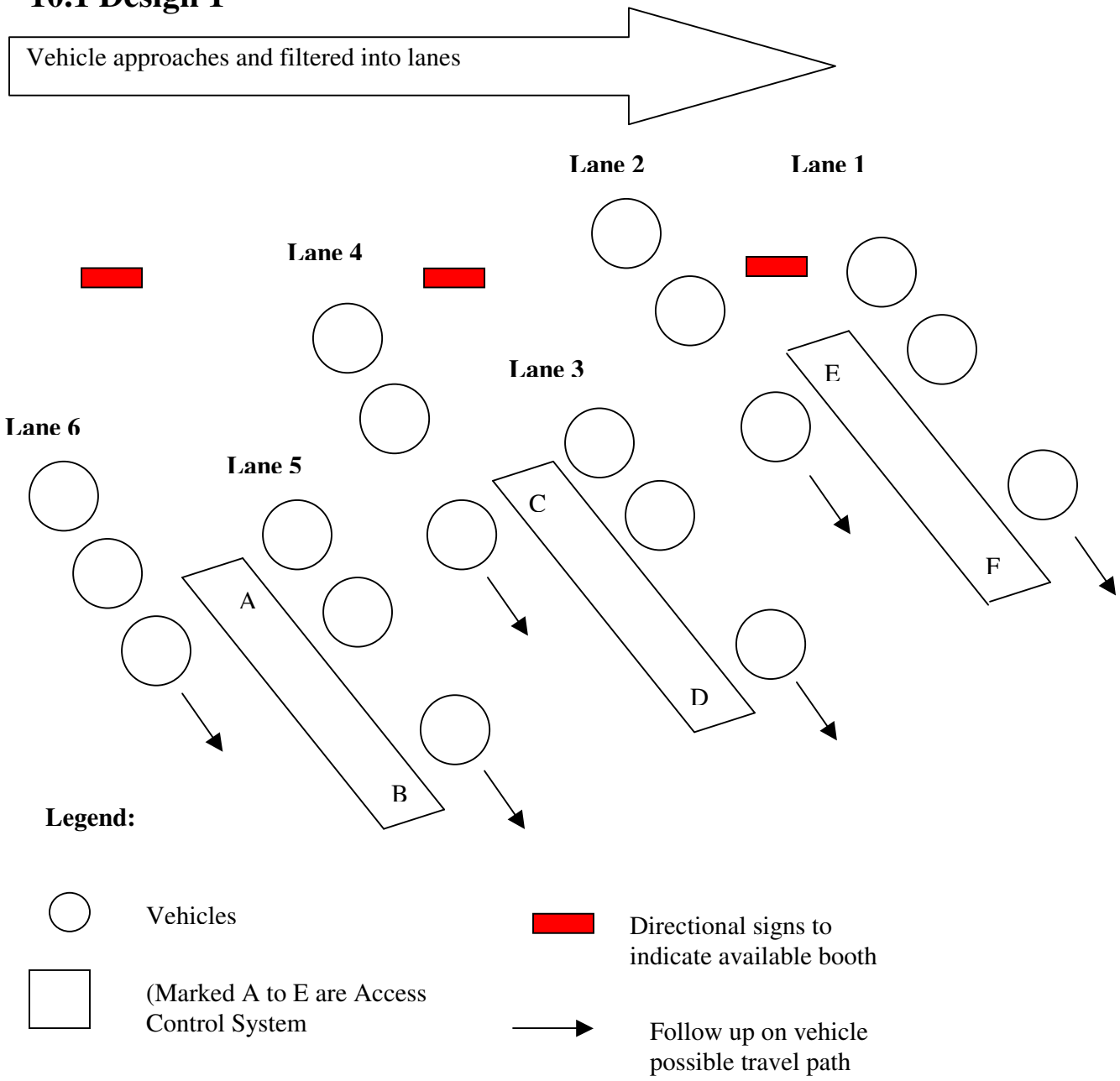

Figure 31: 3 accessing platform, 6 lanes access control

As shown in Figure 31, the helicopter view on the access control system, vehicles approached horizontally from left to right with directional LED placed between each lane. LED directional signs would guide driver to the shortest queue. Immediate after entering into access control, they are filtered into slanted lanes. This is intentionally designed to enlarge drivers' blind spot from what is happening ahead. Indirectly, driver slows down vehicle speed, thus gain command and control over vehicles. Through details studies and analysis, terrorist would only act if they are confidential and assure that their attack would be success. In this case, terrorists are temporary hidden away from advance knowledge of inspection procedure, which create lesser advantageous preparation for the terrorists' intrusion. Therefore, by creating uncertainty ahead, it reduces success rate of intrusion.

From the earlier discussed access control methods, magnetic cards and reader are chosen as the mode of access control. It possesses the advantages as specify and for different events, magnetic cards are stored with the relevant information such as photos, names and number of person tagging along. Upon visitors' arrival at the access control, the issued magnetic card is slide on the card reader, which would determine visitors' Authentication and Authorisation. Information such as arrival time and departure time are captured and churned into list of people remaining in the events. When situation warrant, it could effectively act as a master list for search and rescue work. While access control is verifying the data, a camera beneath the vehicle performs scanning and transmitting to a terminal. Officer viewing the image could perform discreet undercarriage search. As soon data are verified, visitors were allowed to proceed to the portable barrier control.

Although Access Control System has only 3 accessing platforms, it was able to achieve 6 multi phases and channels. Thus, vehicle waiting time and clearance are process timely without unnecessary protracted delay. Depending on the scale of deployment, a 4 accessing platforms, would achieve 8 channels, thus obtaining the earlier calculated result. The anticipated number of customer in the system will be 1.28. For that, the average time spends in the waiting time is 1.54mins and the average number of vehicle in the waiting line for inspection is 0.03.

Aftermath, access control does not need to be equipped with the most technology advanced system in order to deter against terrorist penetration. Although vehicle speed is crucial, there

is no urgent need for a system or LEDs to remind driver to slow down. Inadvertently, driver would reduce speed in sharp corners or bends. Taking advantage of this, I adopted and implement its concept as shown in.

10.2 Design 2

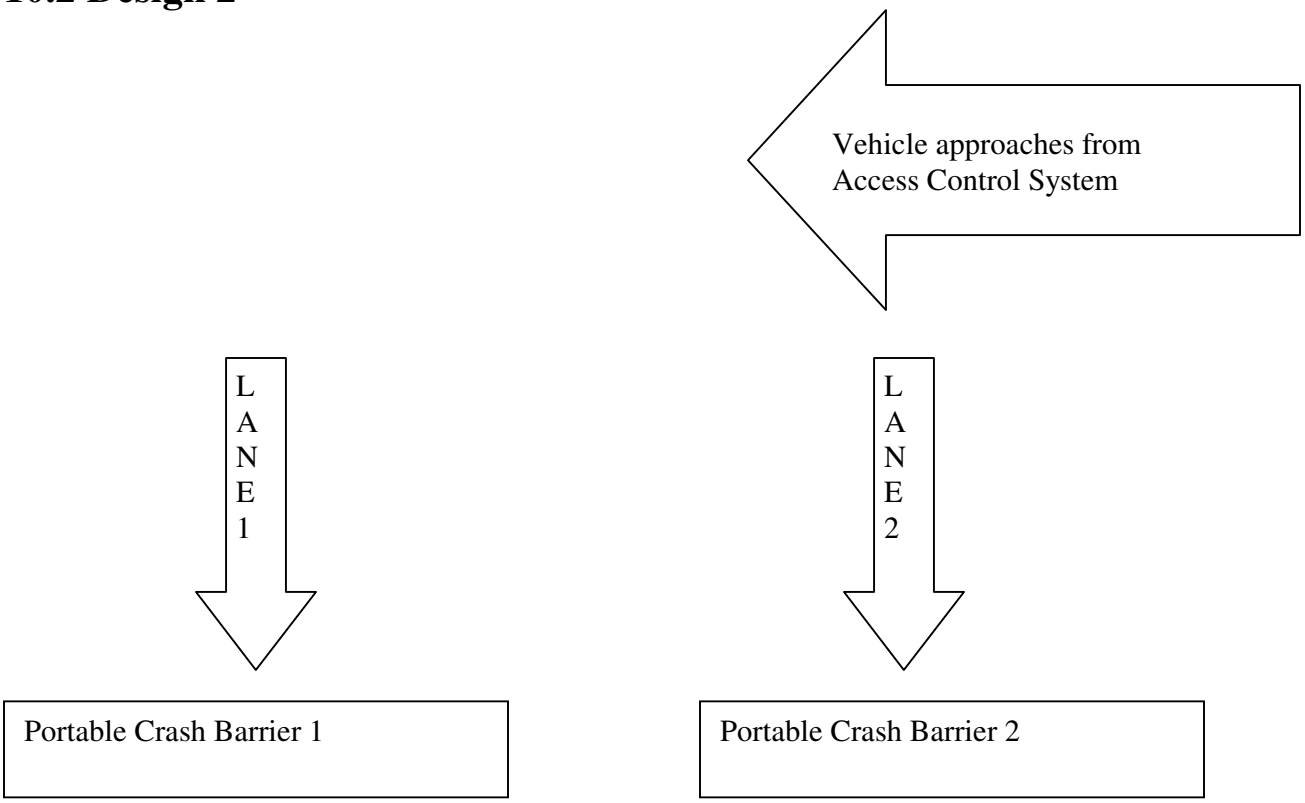

Figure 32: 2 lanes portable crash barrier

After clearance from Undercarriage Inspection and Authorisation Authentication System, vehicles approaches Access Control System in a controlled manner. Studies had shown that vehicles would pick up speed to gain power and impact before they dash through. Thus, with this point in mind, vehicle speed control is vital and requires slow approach.

From Figure 32, 2 lanes portable crash barrier was designed and it served a specific purpose to reduce tremendously from 6 lanes Undercarriage Inspection and Authorisation Authentication System. Although, vehicle initiated queue clearance are rapid with zero waiting queue, vehicles in front of one another act as deterrence against intentional dash

through vehicle. At the same time, it slows down crucial vehicle speed, thus obtaining the ultimate objective without implementing technical equipments.

By default position, crash barrier is always closed. It would only erect on manual operation of a push button, which is accessable by officer on duty only. Onset, officer on duty has around 4 seconds to respond if there is a need to erect the crash barrier. Crash barrier would raise its platform to its full extension within 2 seconds and stopped the targeted dash through vehicle.

10.3 Force field Analysis

Problems	**Solutions**
Driver unaware of available queue	Directional LED showing the available queue
Driver witness the procedure of checks	Slanted lanes to increase drivers' blind spots
No visitors access information	Magnetic cards are used
Long process time	Vehicle undercarriage screened while informations verification
Long waiting queue	4 accessing platforms achieving 8 channels
Vehicle attempt dash through	Increase queue waiting time at crash barrier through reduction of lanes
Fast reaction needed to stop dash through vehicle	4 seconds for full erection

Table 9: Force Field Analysis of Design

From the fish bone diagram studies, the main cause was clearly explicit and stated in cause and effect diagram. Table 9 shows how each stated main cause was countered. Details were mentioned in the design stage.

Aftermath, access control does not need to be equipped with the most technology advanced system in order to deter against terrorist penetration. Although vehicle speed is crucial, there is no urgent need for a system or LEDs to remind driver to slow down. Inadvertently, driver would reduce speed in sharp corners or bends. Taking advantage of this, I adopted and implement its concept as shown in.

11.0 Design of Portable Undercarriage Scanning System

Design is an important aspect of hardware. With improper guidance of design, the system structure/skeleton will not work accordingly. Therefore, before the commencement of system design, factors that probably influenced the designs were noted down and individually considered. This process envisages reducing much anticipated inconvenience and problems. To further ease the complication, design is serrated into 2 parts namely the ramp and camera casing. The following listed the factors for ramp.

- Length of a car
- Width of car tire to tire
- Height from the base of the vehicle to ground and weight
- Portability
- Easy and quick to set up
- Store small and build to last
- Design from commonly available material
- Easy and quick to fabricate

The following listed the factors for cameras casing

- Length of the casing
- Method to extend cables out of the casing
- Length of the camera

11.1 Material Selection

First and foremost, understanding the material properties will initial the correct chosen material. With the essential knowledge on selection factors such as resistance to corrosion, strength of the material, prices and weight, possible material are narrow down, thus easier and faster. Three types of material were considered. They are mild steel, stainless steel and aluminum.

Material	Corrosion	Strength/MPa		Price	Weight/ Mg/M^3		Modulus of Elasticity/GPa	
	Rating	Rating	Value	Rating	Rating	Value	Rating	Value
Mild Steel Alloy 1010A	1	2	200	3	1	7.7	4	207
Stainless Steel 440CA	4	3	462	1	1	7.7	3	190
Aluminum Alloy 7075-T6	3	4	538	2	3	2.8	2	72

Table 10: Material Decision Matrix

From Table 10, a decision matrix was drawn using the scale 0 to 4, 0 being the least ideal and 4 the most ideal. The ratings are tabulated based on material properties and the highest rankings are chosen.

The final material chosen is aluminum because the material is the strongest among the three. It does not rust and most importantly aluminum is the lightest. Although mild steel is the cheapest, it requires extra galvanizing processing to protect from rusting. However, galvanizing processing does not ensure 100% protection. Once the protection layer is scraped off, the material resumed its exposure to atmosphere and rust. Considering the nature of usage is very pone to scratch, it thus make very unsuitable. Stainless steel was not chosen even though it does not rust and possess relatively strong material out of the three because stainless steel is the heaviest and most expensive. Bind by the design factors of portability and ease of setup by 2 people. It is thus not selected.

11.2 Design 1

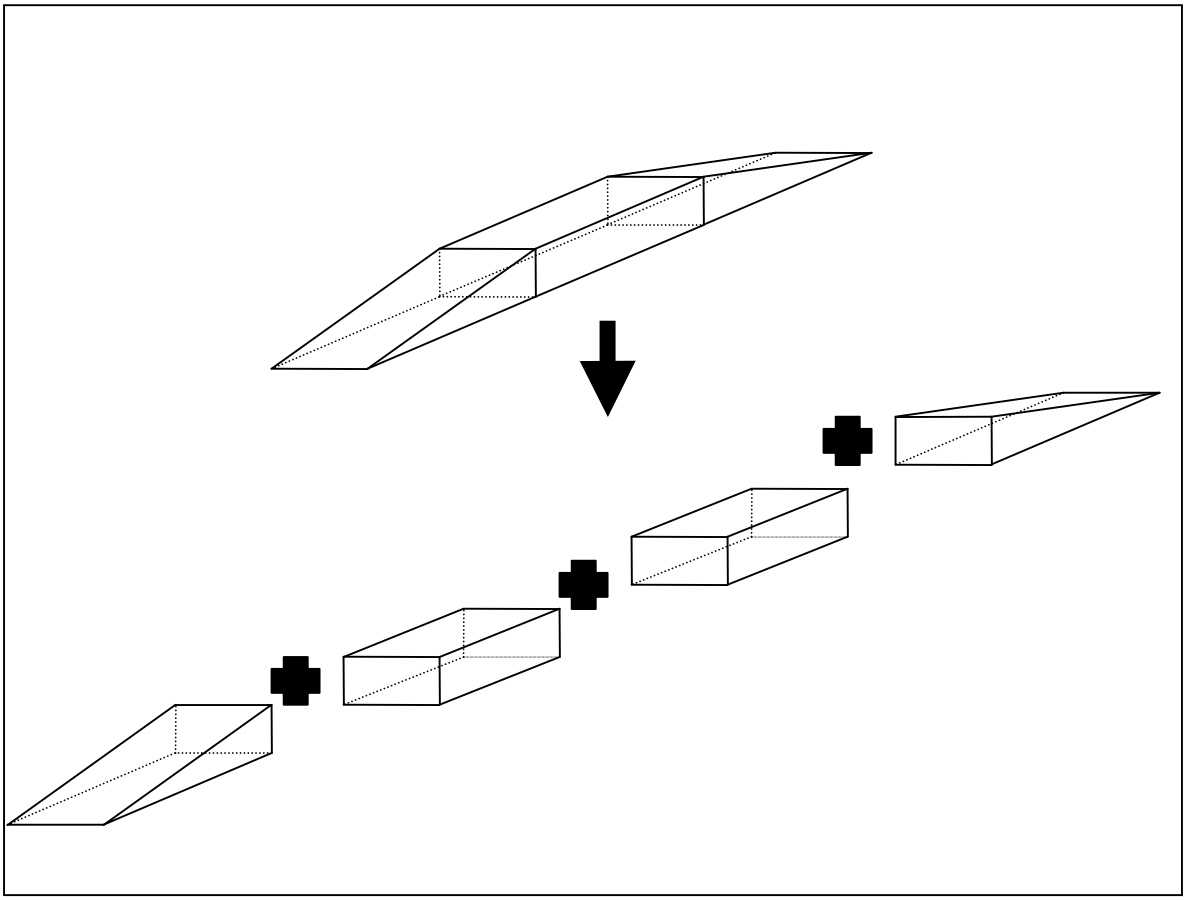

Figure 33: First version of undercarriage design

Thinking along the line that all vehicles have 2 wheels on each side, two separate piece of ramp was designed. The width of the ramp was taken from the average width of various vehicle tires. The ramp was then placed an average car width distance away. Ideally, each side of the wheel would drive up and down from the ramp.

From the initial ramp design, it was separated into four pieces to ease heavy weight and assembly as shown in Figure 33. At the same time, it ease fabrication and individual parts could be replaced and serviced. Inadvertently, heavy cost for a replacement is saved. However, there is a concern of safety. If the ramp failed to stay as apiece when the vehicle drives through the ramp, it would not be suitable for use. Vehicle may fall out from the ramp,

causing damages and resulting in compensation. To resolve this problem, section of the ramp was redesigned as shown in Figure 34

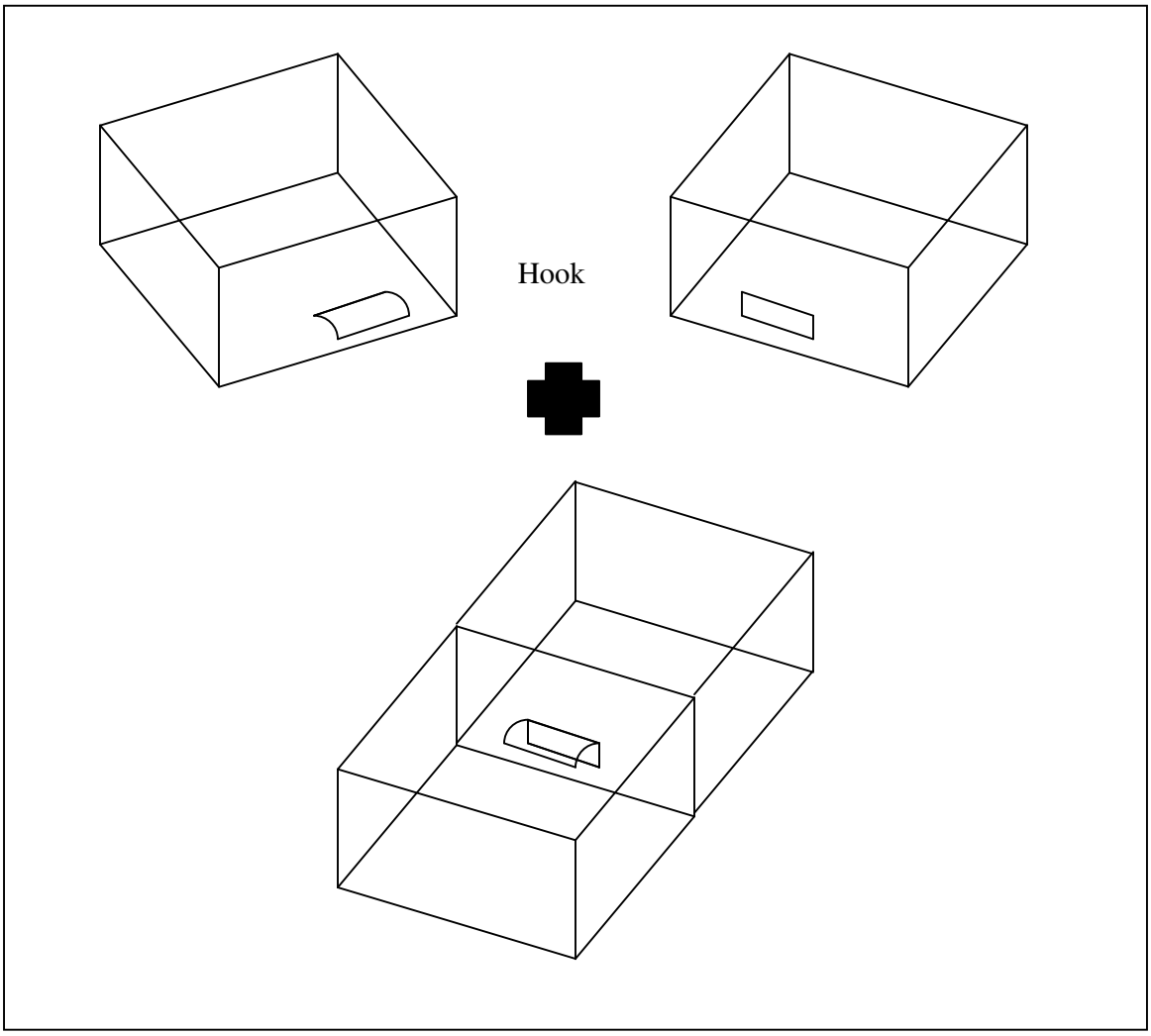

Figure 34: Section of the ramp with hook

Sections of the ramp possess male and female features, where 2 blocks of ramp are hooked on each other. The hook is snugly secured and does not allow break or loose open when in use. Neither does it require technical locking and adhesive. The hook allows easy and not much of a hassle to attach and remove.

Due design consideration was given to the male features (as shown in Figure 34 top left hand diagram) to avoid shape restoration and breakage during rough handling. The male feature is carefully welded to avoid possible of grain distortion and material strength deterioration.

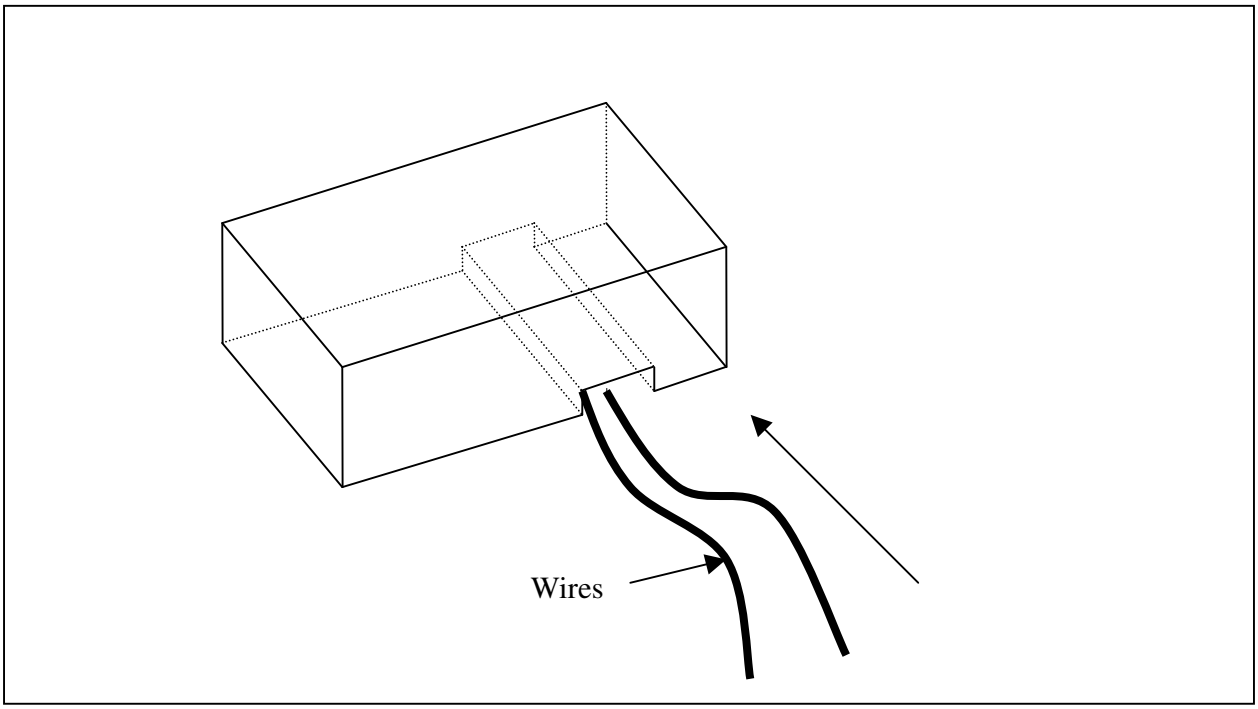

Figure 35: Cameras wiring

Cameras cables were essentially laid from the camera to the viewing terminal. Further problem recurred when vehicles drove over the cameras' cables that were laid on the floor. Obviously, the wires get damaged and replacements are unevitable. As shown in Figure 35 and Figure 36, a small square at the bottom side of the two centerpieces of the ramp was cut. It allows the cables to run under the ramp, thus running cables were not damaged.

The cut was made without determining the strength of the ramp. This was done through proper ANSYS studies of the ramp. The rectangle shape of the cut was determine to be the most optimal.

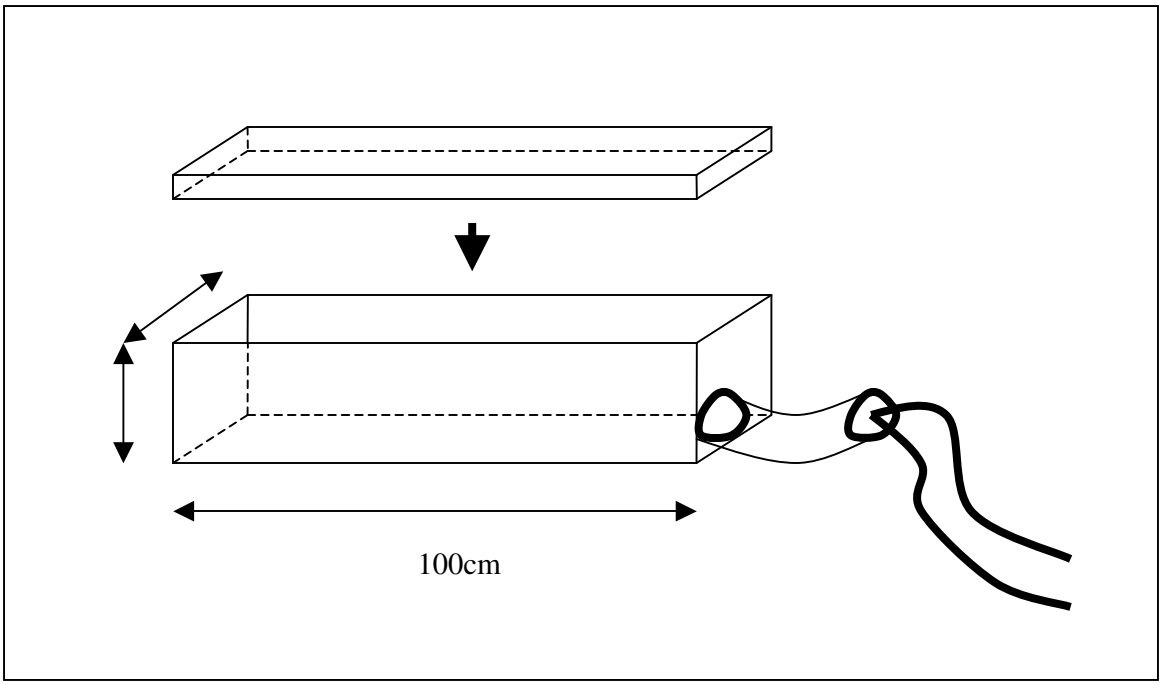

Figure 36: Camera casing design

We determined the measurement of the camera casing from certain areas

(i) Due to the position of the cameras in the casing, the length of the casing is set to be 100cm.

(ii) As for the height for the casing, we chose it to be the same as the height of the ramp. This is to prevent the ramp blocking the camera's view of the vehicle.

(iii) We try to minimize the width of the casing so that it is not bulky to carry.

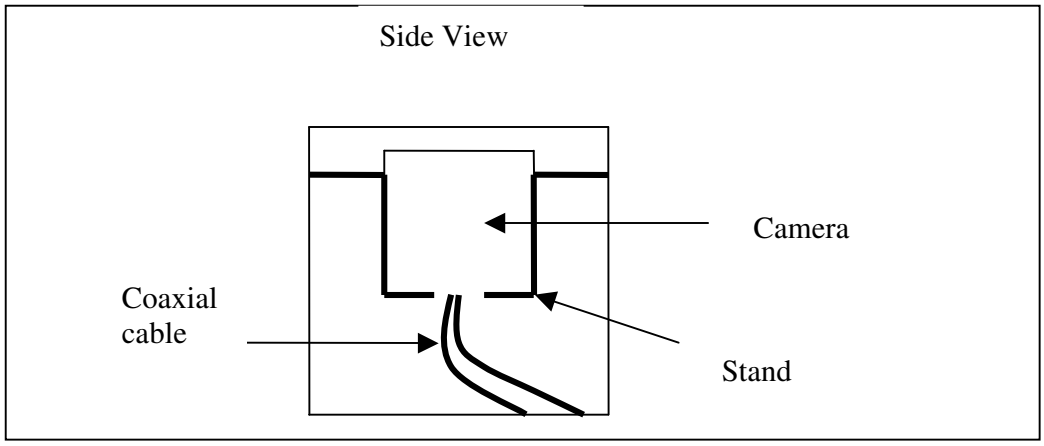

Figure 37: Cross sectional view of camera placing

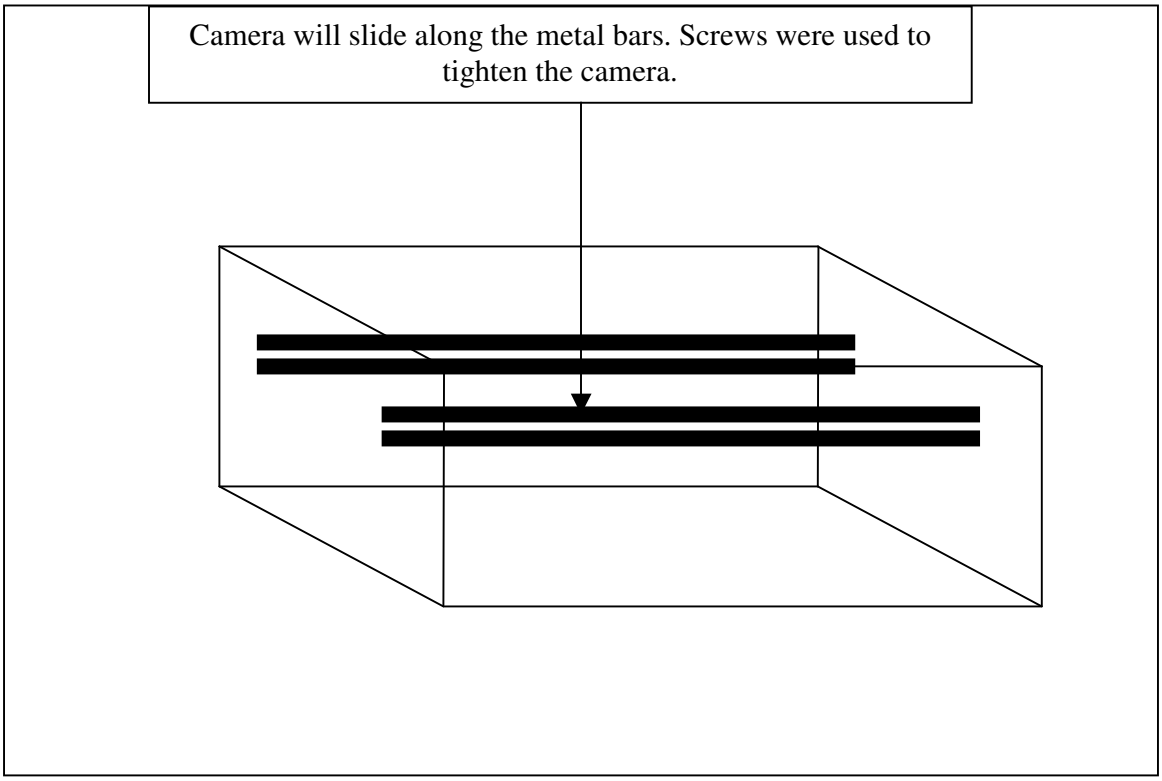

Figure 38: General view of camera placing

As shown in Figure 37 and Figure 38, the camera casing is designed to be adjustable along the horizontal edges of the casing with screws. In addition, the casing provides better camera stability and do not fumble as vehicle move across the ramp. However, the height of camera are affixed and non adjustable. Nevertheless, it does not impose much problem, as camera lens can be focus with fixed height. Due to the confidentiality of information, preceding Figure 39 shows a simplified Pro- E drawing of the undercarriage scanning system.

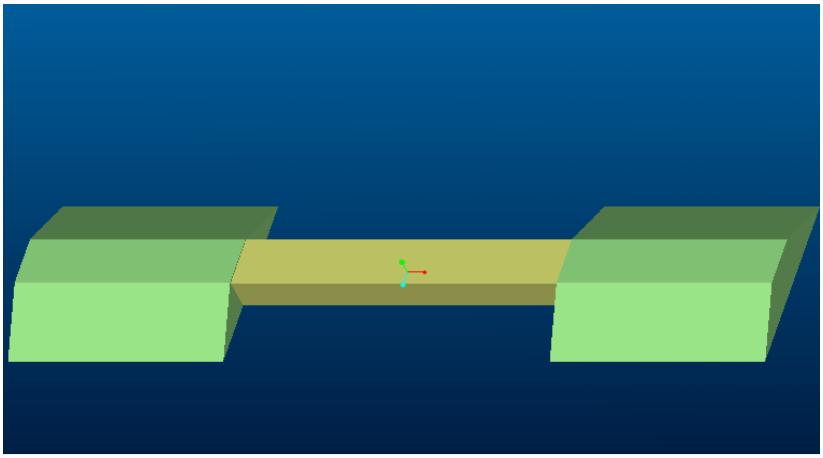

Figure 39: Simplified Pro-E drawing of prototype

The first version prototype ramp was fabricated and tested under the working conditions.

The observation as follow:

The ramp was too steep and motion over the ramp was rough

The adjustment on the ramp width was not possible.

The camera casing gets dirty easily. This result in poor undercarriage image until the dirt is removed.

The dirt removal method cause scratches on the cameras lens

Cameras heights in casing are permanent and do not allow height tolerance changing accordingly.

10.2 Design 2

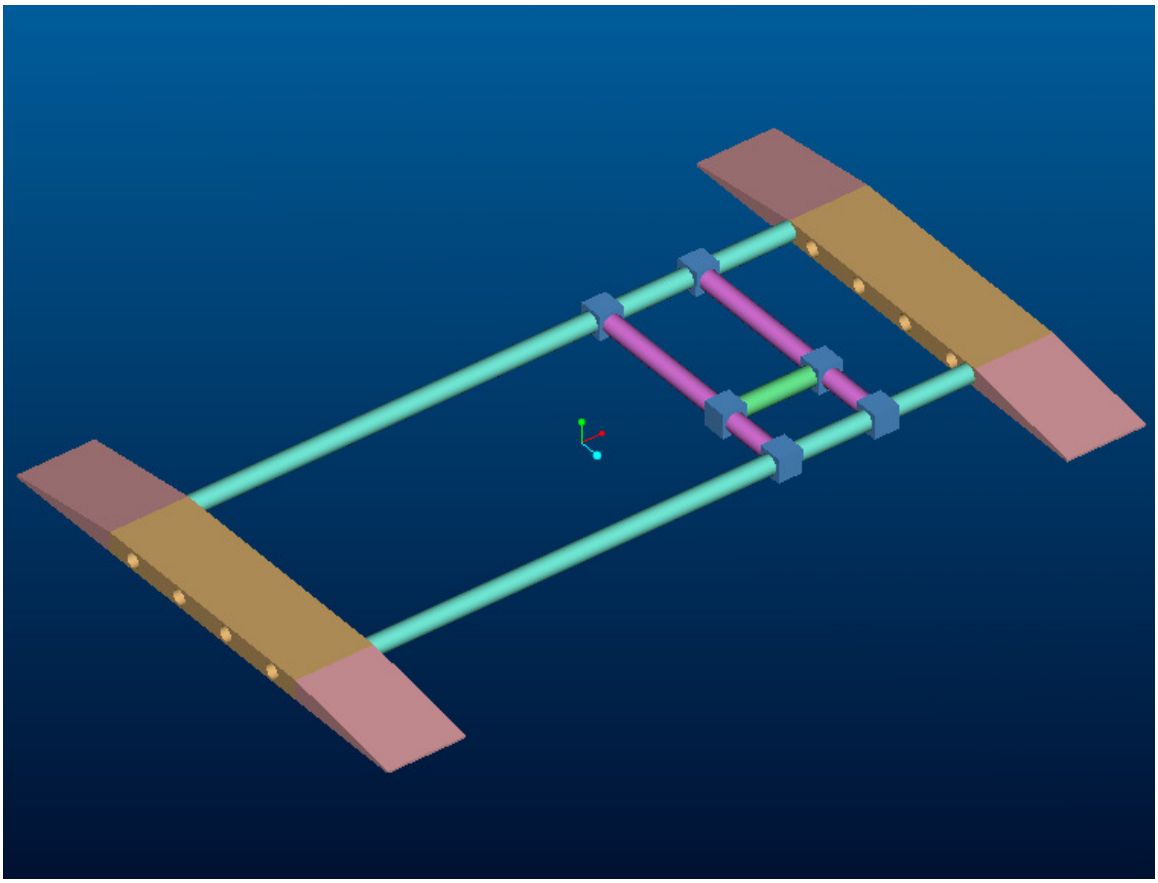

Figure 40: Second version of Undercarriage Scanning System

Undercarriage Vehicle Scanning System was further designed to incorporate search capability. Through the experimented result from the first version of ramp, it was revealed to be too steep and passengers in vehicle felt great hump and uncomforted when vehicle wheels differentiate from the road to the ramp or vice versa. Therefore, the ramp was redesigned with lower gradient slope to allow gentler vehicle movement.

Through graphic design, it suggests that the ramp is much longer. At the same time, the amount of material required increase and that could tantamount to greater cost and weight. Vehicle wheel is able to roll over the ramp at a consistently distributed weight and reduces titling or causing imbalance on the ramp.

The stationary camera was affixed on a plate, which is bearing attached on a movable x and y-axis shaft. The shaft are motor-powered and controlled using a joystick or keyboard. While the vehicle remains in position, waiting for authentication and identification, officers are allow to scan through in search of dubious items. The search covered the length and breadth of an average dimension of a vehicle.

Automatically, the camera returned to its “home” position with a button controlled while await for the next vehicle visit. The search toggles between video and still picture mode. In video mode, the captured images are live and display instantaneously on the monitor screen. This navigation acts as eyes for the officer in front of the screen. Officer may discretion to view the searched undercarriage in still image mode and takes individual shoots to convinced that the

12.0 Evaluation and Conclusion

My above-presented thesis emphasized much on methods to detect the present of IEDs through capturing of vehicle undercarriage image with the use of cameras. At the same time, drivers accessibility are evaluated before they gaining authorized entrance through the use of magnetic stripe. While officer on duty could view through the undercarriage thoroughly with nothing escaping under their nose, it is served only as a system to facilitate and ease the manual work. None of the market system allows fool proof deterrence against terrorist threat or attack. It is not always the case to fight against terrorist with the most high-end technology, mental challenge and various factors contribute to the success rate.

By and large, terrorists continuously acquired new ways to conceal their IEDs with the purpose to achieve their mission. That being the case, security forces are generally expected to keep their guards on toe and remain vigilance and look out for hideout and smuggle. As a saying goes around, it would not be possible for the security forces to remain high vigilance all the time. It takes the security forces to be lucky always but terrorist requires one time of the luck. Therefore, it would not be practical and possible to win a protracted fight solely on keeping on high guards.

In view, there is a demand for continuous improvement and development of intelligence system to detect and deter terrorist success. Intelligence department should work as one with the researchers in coming up with new system and new deterrence method in a common objective. Although intelligence informations are sensitive and critical, it should not be one of the hindrances towards combined efforts. During the understudying of this thesis, many security departments refused to produce substantial statistics and feedback on their current system/methods. Without accurate data, it is thus leveled harder to proceed with a corrective system to the current.

Individual is always limited to the available strength and morale. A group as one will reached its limit where how much it could do. It is only fair for everyone, inclusive of old, young, citizens to play a active role in fighting against terrorism. A force of total defense.

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14.0 Appendix A

University of Southern Queensland

Faculty of Engineering and Surveying

ENG 4111/2 Research Project

PROJECT SPECIFICATION

FOR:	Frederick Chong Chuen Kiong
TOPIC:	Vehicle Undercarriage Scanning System
SUPERVISOR:	Dr Harry Ku
ASSOCIATE SUPERVISOR:	Edmund Cheng Address: 22R Flower Road, Singapore 545473 Phone: 96957199 edchang@singnet.com.sg
ENROLLMENT:	ENG 4111- S1, 2005 ENG 4112- S2, 2005
PROJECT AIM:	This project aims to study the problem of current available vehicle scanning platform. To redesign and enhanced system capability by integration to achieve automation and reduce manpower operation
PROGRAMME:	Issue A, 19th February 2005

1. Research and evaluate existing undercarriage scanning system.

2. Redesign portable scanning platform to overcome predefined problem eg. Blind spot

3. Consideration and selection of strategically mounted cameras to capture critical images and enhance system capability through camera search.

4. Studies on officers' deployment strategies and effect.

5. Design and integrate systems to achieve automation and minimise man labour operation.

6. Design of access control system against intentional dash through situation.

If time permits

7. Design of coloured imaging software with images saving function.

8. Vehicle clearance system to avoid impersonation.

PROGRAMME: Issue A 19th February 2005

1. Determine objective and literature reviews

   Begin : 01st Feb 2005
   Completion : 30th Mar 2005
   Approx. Hours : 60 hours

2. Evaluate existing undercarriage scanning system.

   Begin : 1st April 2005
   Completion : 15th April 2005
   Approx. Hours : 20 hours

3. Studies on types of contraband items and method of deterrence and detection

   Begin : 16th April 2005
   Completion : 30th April 2005
   Approx. Hours : 20 hours

4. Studies on officer deployment strategies and effect

   Begin : 1st May 2005
   Completion : 15th May 2005
   Approx. Hours : 20 hours

5. Project Appreciation Due Date: 16th May 2005

6. Design access control system

   Begin : 16th May 2005
   Completion : 15th June 2005
   Approx. Hours : 40 hours

7. Progress Assessment Due Date: 13th June 2005

8. Design of portable undercarriage scanning system

   Begin : 16th June 2005
   Completion : 15th July 2005
   Approx. Hours : 40 hours

9. Integrate systems to achieve automation

   Begin : 16th July 2005
   Completion : 15th August 2005
   Approx. Hours : 40 hours

10. Evaluate revamped system

    Begin : 16th August 2005
    Completion : 15th September 2005
    Approx. Hours : 40 hours

11. Thesis initial drafting – each chapter in draft form is shown to supervisor so that the thesis can be finished reading by 20 April 2005.

    Begin : 1st October 2005
    Completion : 15th October 2005
    Approx. Hours : 60 hours

12. Final draft of thesis, to incorporate modifications suggested by supervisor.

    Begin : 16th October 2005
    Completion : 30th October 2005
    Approx. Hours : 20 hours

13. Complete the thesis in requested format

    Completion : 1st November 2005

AGREED: _____ (student)

_____ (Supervisor)

_____ (Supervisor)

31/03/05

Date: 19/03/05