

# **Design, Development and Evaluation of a Training Method to Improve Firing Skills on Moving Targets**

*A thesis submitted in partial fulfillment of the requirements for the degree of*

**DOCTOR OF PHILOSOPHY**

**BY**

**KCP PARASARAM**



**Department of Design**

**Indian Institute of Technology Guwahati**

**Guwahati, Assam-781039**

**INDIA**

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Roll No. 166105108

Under the supervision of

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2023



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## **DECLARATION**

This is to certify that the research work in the thesis entitled “**Design, Development and Evaluation of a Training Method to Improve Firing Skills on Moving Targets**” is carried out by me at the Department of Design, Indian Institute of Technology Guwahati, under the supervision of Dr. Urmi Ravindra Salve. The results documented in this thesis are achieved by me and it has not been submitted to any other University or Institute for the award of any degree or diploma.

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### **THESIS CERTIFICATE**

This is to certify that the work contained in the thesis entitled “**Design, Development and Evaluation of a Training Method to Improve Firing Skills on Moving Targets**” by **KCP Parasaram**, a student of the Department of Design, Indian Institute of Technology Guwahati, for the award of the degree of the **Doctor of Philosophy** has been carried out under my supervision and that this work has not been submitted elsewhere for any degree or diploma.

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Krishna Charan Prasad Parasaram  
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## Abstract

The basis for any country's sustained overall growth in a long term, is its ability to ensure fulfilment of minimum basic essentials to all its populace, create a healthy & competitive atmosphere and provide equal opportunities for all, for overall prosperity, progressively and collectively. The underlying foundation for all this to happen is an assured stable and peaceful atmosphere, which is the responsibility of the security forces. Conventionally, world over, external threats are taken care by security (defence) forces and internal security is handled by police forces. In the modern history of security threats, especially in the last 3-5 decades, terrorism has gradually gained gigantic proportions to the tune of becoming a global phenomenon which seriously & significantly affects/ impacts many nations across the world. Of the many ways in which terrorism affects, suicide styled surprise terror-attacks, based on hard-core fundamentalist approaches is a major global challenge that security forces (police included) of many countries are coping up with. These attacks can be divided into two broad categories. First, attacks which target the civilian population, who are generally unarmed and hence cannot be resisted. Second, attacks which are specifically targeted on security personnel (soldiers as well as police), those who are deployed on patrol duties or guarding a check-post, i.e., those deployed on duties of the first line of defence. While there are many multi-pronged measures in place to control/ curb the terror-menace, one common step/ feature i.r.o. many countries is Special Forces (SF), who are highly capable to handle & neutralise such terror threats. Also known as 'Commandos' and/ or by different names in different countries, these SF are considered, every country's most potent force, capable to handle any kind of risk/ threat situations. From the observations based on various terror attacks that have been unleashed in the past on security personnel (police or security forces), it has been observed that, SF do take/ need some time – atleast a few hours, to reach the scene of attack, before they can take over the situation and neutralise the terror threat. So, in all such actual scenarios, it is the security forces of the first line of defence, i.e., those deployed on patrol duties or on check-post duties, who are inevitably the 'first to bear the brunt' of such attacks. In this context, the ability of these security personnel (soldiers as well as police) to fire accurately at those attacking terrorists is highly significant, to nail them down or chase them away or atleast give stiff resistance, till the time additional/ SF arrive. From the training perspective, ability to fire at moving targets during training stage can be considered equivalent to, or a reasonable measure of the ability to fire at moving attackers in real situations. In this context, since moving target training has a significant impact on the preparedness of security forces (police included) to handle modern day terror threats, imparting this skill at training stage is considered important

Weapon firing training is conventionally imparted through actual firing of bullets on static targets in a standard open firing range. Moving target firing can be imparted in two distinct methods. One, by means of physical firing in firing ranges, in which different target movements are generated using independent/ specific mechanisms. It is pertinent to note that, generating different types of target movements physically in an open firing range has considerable practical constraints and incurs substantial cost. Second, by simulation / virtual means, i.e., target movement is generated with the help of hi-tech simulation softwares and associated infrastructure. Simulation method of training has a big advantage that it can virtually generate any type of target movement and even a battle environment. However, all this is possible only at a corresponding high price. Since both the methods are expensive, only affluent and technologically advanced countries have used these methods to impart moving target training to their soldiers. However, the under-developed and developing countries, by virtue of affordability constraints, have limited themselves largely to conventional methods of training, on static targets only. In this context, it can be logically construed that, all those countries

(soldiers & police), dependant largely on conventional methods of weapon training, are not adequately experienced/ exposed to the much-needed moving target firing. Whereas, firing skills on moving targets play significant role in any offensive or counter-offensive operations, while encountering terror attacks. This research study attempts to explore the feasibility of a cost-effective method to impart moving target training using conventional infrastructure, i.e., through standard open firing range, and thus improve the firing skills. The research work includes field trails to validate the proposed method.

Initially, as a first step, the content of moving target training (syllabus) has been designed (formulated) based on a thorough analysis of the movements of attackers in various terror attacks unleashed in the past. Accordingly, Moving Target Training (MTT) has been planned to be imparted on four distinct target motions – Horizontal, Slant, Random motions and on Flash Appearance & Disappearance of target. Designs (2D-drawings) of mechanisms to generate different types of target motions for conceived method of training have been finalised. Designed mechanisms constitute a chassis that can be tracted, and four independent modules, each capable to generate one specific type of motion. Working model (electro-mechanical) is fabricated, based on these designs. Further, the existing method for weapon training (static firing) as well as the existing method for static firing skill assessment have been studied in detail. Refined methods have been proposed, considered more suitable for MTT. Elaborate field trials have been planned/ conducted to evaluate the effectiveness of proposed model to generate various types of target movements as conceived, as well as to evaluate the effectiveness of proposed training method to enhance firing skills/ accuracy on moving targets. Experiment results are satisfactory, and validate the effectiveness of proposed model to definitely improve firing skills on moving targets. Significant features of this proposed training model (method) are:

- (i) It is a pioneering work in the field of moving target training, and is considered a unique model of its kind, for the intended purpose, i.e., to impart moving target training in an open firing range in a cost-effective way.
- (ii) Each type of target motion has been generated using specially designed mechanisms (SDMs), through innovative ways to achieve the said target motions. Working model is fabricated without dependence on any complex/ costly or custom-made spares.
- (iii) The proposed design utilises existing infrastructure to impart MTT. Hence it is considered an affordable & cost effective method, thus ensuring ‘reachability to all’.
- (iv) From the evaluation of results of field trails, it evolved that the quantum of learning of moving target skills by trainees is significantly dependent on two distinct factors:
  - (a) Previous skill grade of firer in Static firing
  - (b) Degree of difficulty to predict target motion

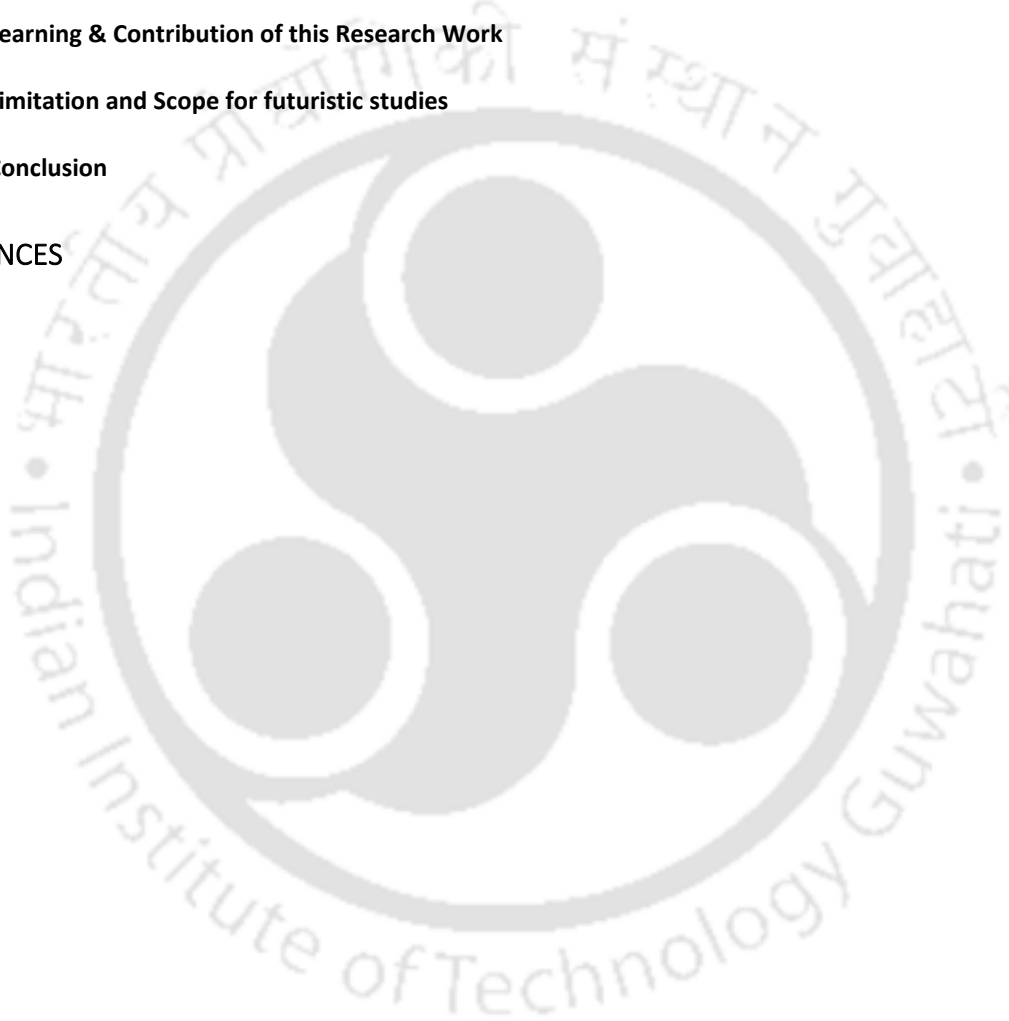
The scope of this research work is limited to explore and identify a suitable training method to impart moving target training using conventional infrastructure, i.e., open firing range, and in turn enhance firing efficiency/ accuracy on moving targets. Further scope exists for futuristic research work, to measure the impact of various training related factors on rate and quantum of learning.

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# Chapter 1: Performance Enhancement Through Improved Training

## 1.1 Introduction

A country's capacity can be defined as the ability of that country or government to perform the functions of providing essential services to all its' populace, work towards solving problems that hinder country's growth and create an atmosphere of opportunities for all, to move towards overall prosperity, progressively and collectively (Enos & Farr, 2013; Kardos, 2010). Various arms and wings of the govt. constantly evolve policies from time to time, to achieve these govt objectives in a sustainable manner (Enos & Farr, 2013). Towards this, establishing & ensuring security and stability is a fundamental necessity for successful political resolution. This function/ responsibility is most effectively undertaken by the military and police forces, collectively referred to as Security Forces (Kardos, 2010). Conventionally, world over, the military forces tackle external threats, and the police forces handle internal threats (Gulati, 2012). A combination of both forces is also used as per situational needs. Historically, when and where-ever there have been prolonged periods of mis-governance, suppression, and/ or partisan politics leading to a feeling of deprivation or state of continuous denial, the oppressed has resorted to violence, to bring in desired changes in the society and in political systems (Kardos, 2010; Iheonu & Ichoku, 2021). Extreme poverty, illiteracy, and lack of growth-opportunities for prolonged periods, have always further served as catalysts to this phenomenon (Iheonu & Ichoku, 2021; Jamwal, 2003). In general, use of violence to achieve political objectives has become a norm/ trend of the weak/ oppressed against the authorities, across the countries (Jamwal, 2003). Over the decades, such motives have gradually taken the shape of / transformed into terrorism (Kardos, 2010; Iheonu & Ichoku, 2021). Terrorism can be defined as the deliberate use or threat of violence by individuals, and non-state and state actors, against targets that are so chosen, in order to manipulate a wider audience for political, ideological, religious or criminal goals (Mogire & Mkutu, 2011). In the modern history of mankind, world over, terrorism has become a modern day's night mare which many countries / govts are trying to handle (Mogire & Mkutu, 2011).

History reveals that, in general, some of the major factors that fuelled terrorism are irrationality, forced denials, xenophobia, fanaticism and religious extremism (Jamwal, 2003). Ethnic disharmony, rebel movements and insurgencies threaten more than one-third of all the present member-countries of the United Nations (Jamwal, 2003). Therefore, it is considered necessary to correctly understand/ analyse the intricacies of the changes taking place in the international order and their repercussions on the political, socio-economic, cultural, and ideological components of society so that meaningful strategies can be formulated for the future progress, development, and for the well-being and survival of mankind (Trossen, 2010; Deger & Smith, 1983; Jamwal, 2003). Many significant changes have been noticed in the modus operandi and profile of the terrorists during the mid-twentieth and twenty first centuries (Deger & Smith, 1983; Jamwal, 2003). Contemporary terrorist organisations have assumed a transnational character. They operate beyond the national boundaries of their target states (Jamwal, 2003). A significant point to be noted is the striking difference/ shift in the thinking strategy/ pattern of these terrorist groups/ organisations. Till early twentieth century, the terrorist groups operated with a philosophy of resentment against the atrocities of the then

governments, where in, they (militants) reconciled to the fact that death is inevitable in their struggle. Hence, all terrorists who died during action were given the status of martyrs. However, all this changed in the contemporary context. In the twenty first century, these terrorist organisations are observed to grant/ assume a self-proclaimed superior status to themselves. Accordingly, they voice their strong opinion that, they, and only they, know the truth and therefore ordinary law does not apply to them (Trossen, 2010; Nesser et al, 2016; Jamwal, 2003).

## **1.2 Spread of Terrorism in Modern Era**

Suicide styled attacks +have become the mark of modern-days' terrorist attacks. These attacks can be considered as the biggest and common-most scare/ worry that haunts various countries across the globe (Trossen, 2010; Nesser et al, 2016). Contemporary terrorism carries out acts of violence, mostly as state-sponsored large-scale operations surpassing all national boundaries (Jamwal, 2003; Trossen, 2010). With the developments in scientific, technological and communication knowledge, terrorists and states sponsoring terrorism, are also gaining access to most sophisticated & advance weapons as well as to non-conventional weapons of mass destruction (Jamwal, 2003; Enos & Farr, 2013).

Globally, there have been catastrophic consequences as a result of terrorism. In 2016 alone, there were about 11,672 terrorist incidents across the world which led to 25,600 deaths, as brought out in Global Terrorism Index, 2016 (Jamwal, 2003). Europe faces an escalating threat from terrorism, and it is not an exaggeration to state that more people have been killed by terrorism related violence in Western Europe in 2014-2016 than in all previous five years combined (Nesser et al, 2016; Nesser & Stenersen, 2014). With territorial control, economic muscle and thousands of recruits in its ranks, the terror organisations pose severe challenges to security forces of many nations (Nesser et al, 2016; Nesser & Stenersen, 2014). Libya-supported Irish Republican Army (IRA), Arab terrorist groups, Iran supported Hezbollah against Israel, Iraq-supported Hamas against Israel, and Pakistan supported terrorist groups against India are some of the other major examples of global spread of terror (Kardos, 2010; Mogire & Mkutu, 2011; Jamwal, 2003). With specific reference to India, the threat from terrorism to India's national security is real and alive, to which the Indian security forces (military, state & central police forces combined), have jointly put a formidable defence to serve as deterrent as well as to control /curb the terror menace, to a large extent (Jamwal, 2003).

### **1.2.1 Impact of Terrorism on a Nations' Progress**

There have been several studies on the impact of terrorism on economic growth across different regions (Deger & Smith, 1983; Iheonu & Ichoku, 2021). A study was conducted by Akinci et al. for the period 2002-2011, involving a total of 152 countries, in which 45 were developed countries, 77 were emerging countries and 30 were underdeveloped countries (Iheonu & Ichoku, 2021). This was to study the diverse influence of terrorism on economic growth based on the level of development in a country. The study revealed that the effect of terrorism is more intense in developing and underdeveloped countries as compared to developed countries. Other similar studies also evolve with the same view point that, low-income countries are affected more by terrorist attacks as compared to high-income countries (Tian et al., 2020; Iheonu & Ichoku, 2021). Another Study on 147 countries for the period 1968–2002 by a panel headed by

Crain and Crain (2006) revealed that a decline in terror activities increases national income (Iheonu & Ichoku, 2021). It is thus evident and hence can be stated that, suitable methods and mechanisms to curb terrorism, commonly termed as Counter-Terrorism Operations (CT Ops), can play a significant role and are very essential to ensure a secure and stable environment, which in turn, paves the way towards sustained economic development & overall prosperity of the nations (Enos & Farr, 2013; Gulati, 2012; Jamwal, 2003). Security forces – military as well as police, are the sole agencies responsible for successful implementation of Counter-Terrorism Operations (CT Ops) (Kardos, 2010; Trossen, 2010). CT Ops can be broadly divided into two categories. One, is capability enhancement of security forces to handle/ curb terror activities. Second, is the long-term strategic planning which focuses on govt backed initiatives to resolve the issue(s) at the root level, including amalgamation of offended sections in the main stream politics / governance (Kardos, 2010; Trossen, 2010). The biggest draw-back of these strategic initiatives is that they are highly time consuming, even upto decades, and further more. This aspect attains even higher significance in the context of terror-affected zones because, stability and reconstruction in such affected zones is heavily dependent on military's (security forces') ability to halt residual violence and to ensure sustainable peace in such a dangerous & precarious environment (Enos & Farr, 2013; Trossen, 2010). An important aspect to be noted and highlighted is that, till the time long-term initiatives yield expected results, the security forces need to be prepared to handle, counter, and nullify terror attacks, through-out this period (Trossen, 2010). History has enough proof that, in the time dimension, long drawn-out insurgencies are known to result in upward spiralling of lethality of weapons and equipment used by the opposing forces, refinement and innovation in tactics employed (Gulati, 2012; Mogire & Mkutu, 2011). Thus, the role of security forces and the significance of their preparedness to counter militant attacks has a direct bearing on ensuring a conducive and sustainable environment for the progress of a nation (Kardos, 2010; Enos & Farr, 2013). Training of security forces in CT Ops, in order to be able to, and be capable enough to handle such terror threats is hence a very important aspect (Trossen, 2010).

### **1.3 Counter Terrorism (CT) Measures: Overview**

Lack of CT capacity due to institutional weakness has been identified as the prime reason for any country being targeted and continues to be threatened by terrorism (Mogire & Mkutu, 2011; Kardos, 2010). Thus, the core of CT strategy is dependent on institutional development to provide requisite CT training and equipment to the country's security forces (military & police), as well as to the law enforcement agencies (Nesser et al, 2016; Deger & Smith, 1983). The United States of America, over the years (decades), has invested a significant share of its budget in the development of well trained and equipped anti-terrorism organisations to handle various facets of terrorism, independently, as well as collectively (Mogire & Mkutu, 2011). The USA has not only built its own CT capacity, but, as a part of strategic foreign policy, also assisted many friendly foreign nations to enhance their respective CT capacities, in order to favour/ support US' interests (Mogire & Mkutu, 2011; Trossen, 2010; Iheonu & Ichoku, 2021). Towards this, various organisations/ units/ forces have been established by USA. For example, the National Security Intelligence Service (NSIS) has been created to identify threats, collect and analyse intelligence. The National Counter Terrorism Centre (NCTC) was established to develop a long-term CT strategy, collect intelligence, and coordinate regional CT efforts. The Anti-Terrorism Police Unit (ATPU) was set up to plan and execute anti-terrorism operations.

The Joint Terrorism Task Force (JTTF) was established to control, coordinate, and command various government agencies involved in combating terrorism. And, the Special Prosecution Unit (SPU) was set up in the attorney general's office to prosecute terrorist offences (Nesser et al, 2016). Thus, USA and other such developed (rich) nations have paved way in demonstrating that effective handling of terror menace needs robust mechanisms in place, to ensure suitable CT training and comprehensive approach (Kardos, 2010; Iheonu & Ichoku, 2021; Mogire & Mkutu, 2011). As may be easily inferred, this entails huge budget for prolonged periods, which all countries cannot afford to, especially, the under-developed and developing countries (Iheonu & Ichoku, 2021; Mogire & Mkutu, 2011). In this context, it can be stated that developed countries such as USA, Russia, France, UK, etc have adequate quantum of well-established training infrastructure to train all their soldiers to meet their respective countries' security needs (Ejaz, n.d; Crowley et al, 2014; Fox, 2005). However, in case of developing and under-developed countries, budgetary constraints do impede such countries' efforts to establish desired/ adequate training facilities/ infrastructure to (Crowley et al, 2014; Fletcher, 2009; Behera, 2017; Fox, 2005). Hence, in the absence of robust and adequate CT training mechanism, countries with inadequate infrastructure are likely to be more vulnerable and susceptible to terror attacks fait accompli (Iheonu & Ichoku, 2021; Deger & Smith, 1983; Mukherjee & Malone, 2011).

### **1.3.1 Vulnerability of Security Forces to Proxy Wars/ Terror Attacks**

In a conventional war, the actions of enemy can be reasonably anticipated, especially with respect to the predictability of an imminent attack. Contrarily, the proxy warfare through fidayeen styled terror attacks is completely different, where, the time as well as location of attack, both, are most unpredictable (Jamwal, 2003; Nesser & Stenersen, 2014; FRANCE 24 English, 2021). In fact, it is this element of unpredictability that makes it more dangerous and ghastlier, thus mounting immense pressure on soldiers for prolonged periods, and in turn adversely affecting the morale and psyche of security forces (Shah, 2020; Gabel et al., 2020). Guerrilla/ Jungle warfare is terrain specific which further adds to the difficulty level, for the security forces to cope up with (Jamwal, 2003; Mogire & Mkutu, 2011). These features are largely common to all militant groups across the globe, be it the militants operating in Libya, Kenya and North-Africa, the Arab and Palestine militants in Israel, the ISIS militants, the Afghan and al-Qaida groups or the Pakistan sponsored militants (Jamwal, 2003; Mogire & Mkutu, 2011; Mukherjee, 2016). In all such terror attacks, the most common features are:

- Attackers choose a specific vulnerable target after a thorough recce. Attacks are carried out by a single attacker (lone-wolf attacks) or a small group of well-equipped armed militants.
- Attackers have been observed to possess sophisticated weapons and hi-tech communication devices. They are trained/ psyched to even sacrifice their own lives to achieve their motive.
- These attacks are always unleashed as a ghastly surprise, on a guard post or security check point or a patrol team even a convoy transporting troops. The aim is to breach the security and cause maximum possible damage, and thus establish the supremacy/ dominance of terror forces over the security forces. The broad motive

behind such attacks is to bleed the security forces perennially and in turn affect their morale.

- The international media attention/ publicity gained through such attacks is thus used to compel govts, and for leveraging their demands.

#### **1.4 Special Forces to neutralise Terror Threats**

World over, many countries have multiple units of ‘Special Forces’, consisting of specially trained soldiers, commonly known as ‘Commandos’ who are specially trained to handle ghastly terror attacks, which are more famously known as ‘fidayeen attacks’. Commando training is very elaborate, rugged, extremely tough and all-inclusive so that they remain unconquerable (Couch, 2007; Conboy, 2012). Hence, they are rightly described as representatives of the respective country’s most advanced and invincible security force. Depending on their specific expertise, these commandos are known by different names in different countries (Sutherland, 2011; Ejaz, n.d). Marcos of India, Royal Marines of UK, Sayeret Matkal of Israel, Special Service Group (SSG) of Pakistan, Spetsnaz & Alpha Group of Russia, National Gendarmerie Intervention Group (GIGN) of France, Green Berets & Delta Force of USA, are a few examples of the world-famous commando groups (Zazanis et al., 1999; Hunt et al, 2013; Chandramohan, 2013). Some of the other special forces in India are the Para (Special Forces) & Ghataks of Army, Garuds of Air Force, National Security Guards (NSGs), Special Protection Groups (SPGs), and other equivalents. All these forces are specially trained to handle extremely high-threat situations such as terrorist attacks, hostage-rescue operations, etc, and neutralise such attacks with their extraordinary fighting skills (Pant & Lidarev, 2018; Katoch & Datta, 2013).

Combat training of security personnel (soldiers as well as police), to successfully transform them from their ‘young novice recruit/ trainee’ stage to that of a ‘ready for combat’ status, is an elaborate, intense and time-consuming process with considerable degree of hardships as well as risks (Roosa, 1998; Ramesh, 2012; Destadio, 1991). Soldierly skills are imparted to recruits (trainees) in a highly disciplined regime, in which their combat skills are gradually and progressively enhanced, through a methodical approach (Bell, 1986; Maleki et al, 2012). Apart from physical & mental toughness training, combat training includes adept handling of weapons. Along with this, a very specialised skill of shooting accurately at static/ moving targets is also imparted (Johnson, 2007; Crowley et al, 2014). Periodic/ regular weapon firing practice gradually improves and results in excellent coordination of psychomotor skills. This in turn results in improved firing accuracy progressively, with time (Johnson, 2007). Thus, in the context of combat training, it is pertinent to note that even for regular security forces (soldiers as well as police), combat training, which is inclusive of weapon training, necessitates huge infrastructure and associated running costs/ maintenance support. In other words, combat training as well as weapon firing training are associated with huge capital as well as revenue expenditure (Bell, 1986; Fletcher, 2009). It is for these budgetary constraints that, in under-developed and developing countries, there are limited avenues, even for training of regular forces (soldiers as well as police) (Kardos, 2010; Mogire & Mkutu, 2011; Behera, 2017). Comparatively, the infrastructure and equipment required for ‘commando training’ is even further higher and hence costlier too (Fox, 2005; Chandramohan, 2013). Accordingly, the avenues for commando training are even further lesser, as compared to the number of training establishments for regular security forces, i.e., soldiers & police (Behera, 2017; Fox, 2005). It

is also pertinent to note that, by virtue of the training imparted, weapon firing skills of soldiers in general is appreciably good / of high order (Sabharwal et al, 2012; Saus et al, 2006; Toomepuu, 1980). Further, in case of commandos, these firing skills are comparatively even much higher, including their ability to fire accurately, even at moving targets (Conboy, 2012; Fox, 2005; Salas et al, 2006). This very high order firing skills of commandos is attributable to a combination of their personal traits as well as to their gruelling training. As such, the combat skills of commandos are many notches higher than that of regular combat soldiers or police personnel (Couch, 2007; Fox, 2005). This is the prime reason to deploy commandos/ special forces to neutralise ghastly terror attacks or very high threat situations.

#### **1.4.1 Regular Forces vs. Commando Forces: Handling of Terror Attacks**

Though it is a known fact that the Special Forces (also known as Commandos) are very well trained and hence most suitable to neutralize any kind of terror attacks, it is important to note that, whenever an attack occurs, Special Forces need some time to reach the scene of attack and that the regular (patrol) forces are the ones' who respond to such attacks first. The 2015 terror attacks of Paris (France), various terror attacks of 2016 in Europe, the Mumbai terror attacks (India) of 2008 are few such examples (EuroNews, 2016; FRANCE 24 English, 2021; Badri-Maharaj, 2009). Further, in countries with wide geographical spread like India, it takes even more time for the Special Forces (say atleast 6 hr or more), to reach to the spot where attack has been unleashed and to take control of the situation. For example, Mumbai attacks of 2008, or the Pathankot air base attack of 2016, or the Sukma-Bijapur Maoists' attack of 2021 are a few examples to highlight the quantum of time (delay) taken by Special Forces to arrive at the scene (place) of attack (Badri-Maharaj, 2009; Shankar et al, 2011; Sukma-Wikipedia, 2021; Pathankot Attack: 2016). From the practical experiences and observation of various actual terror attacks across many countries in the past, it has been observed, and hence can be stated that, whenever a terror attack occurs, the 'first respondents' to bear the brunt of any such attacks shall be (are) the front-line foot soldiers (or police) deployed as the first line of defence, performing the patrol duties or guard post duties, to guard a security check-point or area (Chandramohan, 2013; Badri-Maharaj, 2009; Mohanan, 2009; Chhattisgarh Naxal Attack, 2021; EuroNews, 2016). Hence, in all cases when a terror attack occurs, these soldiers of the first line of defence, are expected to thwart or atleast resist such terror attacks, till the time Special Forces arrive. From the point of view of effective retaliation to such terror attacks, the ability of front-line foot soldiers (first line of defence) to fight such attacks, matters a lot, especially in terms of their ability to 'fire accurately' at attacking terrorists or miscreants, in order to nail them (terrorists) down (Chandramohan, 2013; Badri-Maharaj, 2009; Chhattisgarh Naxal Attack, 2021). It is a fact that this single skill of 'accurate firing' of the first-line soldiers (police included), plays a significant role in deciding the outcome of such CT operations (Ramesh, 2012; Hosmer, 1990; Maheshwari, 2017).

#### **1.5 Moving Target Firing Skills: Training Perspective**

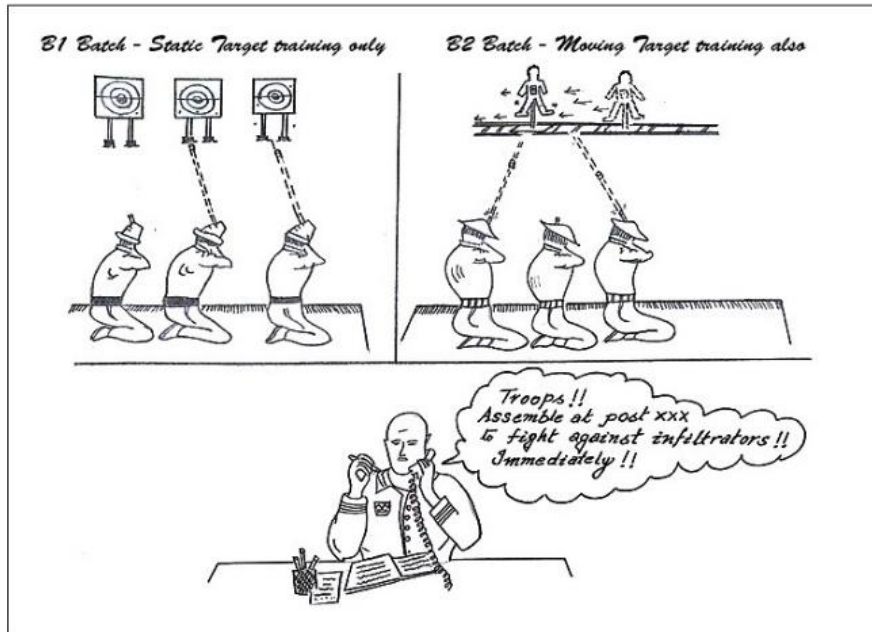
In conventional wars, the enemy soldiers (attackers) position themselves in a bunker or an equivalent guarded place, from where they fire/ fight. Thus, in this context, they can be considered as relatively 'static targets'. Whereas, in case of various terror attacks, as observed from various attacks unleashed in the past, the attackers do not remain stationary in one place/point, but keep moving swiftly from one point to the other, with an intent to attack or to

escape, after attack (Shankar et al, 2011; Pathankot Attack, 2020). Thus, these ‘moving attackers’ can be considered as equivalent to ‘moving targets’ (Ramesh, 2012; Badri-Maharaj, 2009; Operation Black Tornado, 2018). From the point of view of weapon firing training, assuming that all other training-related factors such as physical toughness, agility, mental alertness, deft handling of weapons, etc are all common to all trainees, it can be logically said that ability of soldiers (or police) to ‘fire accurately at moving targets’ during training/ practice sessions, can be considered as equivalent and as a reasonable measure of their ability to fire at ‘moving attackers’ in actual combat operations (Ramesh, 2012; Johnson, 2007; Crowley et al, 2014; Salas et al, 2006 ). From the point of view of ‘security-preparedness’ for CT operations, it is considered relevant to review as to whether the front-line foot soldiers (police inclusive), who are commonly deployed on patrol duties or deployed on routine security duties, are adequately capable to handle modern-day threats (terror attacks) or not? The focus is on soldiers/ police of the first line of defence because, it has already been established that these are always the ‘first respondents’ to bear the brunt of any such attacks. And in this context, their retaliation skills in terms of their ability to fire accurately at moving attackers (targets) matters significantly, either to nail the attackers or to chase them away or to atleast give stiff resistance, till the time Special Forces arrive. And it is self-explanatory that, these firing skills, can be best imparted during and through methodical training only. The same is explained through a hypothetical analysis at para 1.5.1 below.

### **1.5.1 Importance of Moving Target Training at Training Stage: Hypothetical Analysis**

In all combat trainings for weapon firing, static-target firing is the primary step to impart basic firing skills to trainee soldiers (or police) and is considered very essential (Couch, 2007; Destadio, 1991; Sabharwal et al, 2012). The psychomotor skills coordination in terms of alertness and reaction time is effectively imparted through a methodical training process (Maleki et al, 2012; Roosa, 1998). With adequate training & experience on static target firing, every trainee (soldier or police), apart from gaining proficiency to fire at static targets, is likely to develop certain basic degree of skill (ability) to fire at moving targets also, purely by virtue of their individual inherent learning and adaptation skills, (Schneider, 1985; Ohlsson, 2011). However, the fact (short-coming) that is highlighted here is that this degree of firing skill on moving targets, acquired through natural flair or instinct of individuals, shall be non-uniform and far-far lesser than the skill that can be imparted through a ‘well-structured training program’ on moving target firing (Salas et al, 2006; Rossett, 1987; Talandová & Adámek, 2014). Feedback obtained from a preliminary survey of weapon training institutes (comprehensive details about the survey are covered at chap 1.9 subsequently) also has indicated that moving target training at initial training stages, in a structured format, is likely to have a positive impact on the firing proficiency. The concept is explained below in the form of a pictorial depiction, highlighting the relative advantages that are likely to be accrued through a well-structured training program on moving targets.

Let it be presumed that there are two batches of soldiers, Batch1 (B1) and Batch2 (B2) as depicted in Fig1.1 below. B1 batch is trained only on Static Target firing, whereas B2 batch is additionally trained on firing at Moving Targets also, over and above the training on Static Targets. Let it also be presumed that all other conditions of training to both the batches are exactly similar.



**Figure 0.1 :** Scenario 1 - Training Phase

In a hypothetical situation, at the end of training, let it be presumed that there is an actual terror attack on a security check- post or a vital installation, and these soldiers/ police are required to fire at the enemy. In such situations, it can be logically presumed that shots fired by B2 Batch, i.e., those trained on moving target training, are more likely to hit the target (enemy) accurately as compared to the shots fired by B1 Batch, who are most likely to miss the target (enemy) since they are not trained on moving targets. Presuming that all other conditions of training remain the same, it can be reasonably construed that this ability of B2 batch to fire accurately at moving targets is purely attributable to their structured training program & exposure on firing at moving targets, over and above the static target firing. The same is pictorially depicted in Fig 1.2 below.



**Figure 0.2 :** Scenario 2 - Real-time Operation

### **1.5.2 Difference between Combat Firing and Sports Firing**

It is also relevant to note that weapon firing skills of soldiers (police included) is completely different from that of the sports athlete firers who participate in firing-competitions. Weapon firing training imparted to soldiers and police is aimed to impart efficient firing skills to security personnel to fight against enemy, either in self- defence or for offensive and counter-offensive operations (Johnson, 2007; Crowley et al., 2014). Whereas, the weapon firing training imparted to sports personnel is aimed to improve their firing skills and accuracy, in order to make them highly competitive, so that they can participate/ compete in the prestigious and renowned competitions such as Olympics or equivalents (Barth & Dreilich, 2011; Monzoni et al., 2018). Apart from this, another fundamental and distinct difference is that, sports personnel are expected to demonstrate their best performance in a ‘peaceful and conducive environment’ (Monzoni et al., 2018; Portenga et al., 2012). Whereas, security personnel are expected to demonstrate their firing skills in ‘adverse conditions’, when their lives are at risk (Crowley et al., 2014; Toomepuu, 1980). This research study is associated with and focussed on weapon firing skills imparted to security personnel and not to that imparted to sportsmen.

### **1.6 Existing Training Methods for Moving Target Firing: Developed vs Developing & Under-Developed Countries: An overview**

Weapon firing practice for security personnel, soldiers as well as police, is conventionally conducted in a designated place called as ‘Firing Range’. Conventionally, it is located in an isolated location, away from human habitation, and is open to atmosphere. The distinct features of a Firing Range and other associated aspects are covered in detail in Chapter 2 subsequently. Both, static as well as moving target training can be imparted in firing ranges, physically. The detailed description of methods of training is discussed subsequently below (at Chap1.8). Here, the focus is to understand the factors associated in creating/ developing necessary infrastructure to impart weapon firing training, more specifically, moving target training. Static target training is imparted conventionally imparted in open firing ranges, in which, static targets are placed at a designated location. Firers are required to fire at these targets from a specified distance. Firing skill of firers is assessed based on the ability to fire at the target. More details are covered comprehensively in subsequent chapters – chap 2 & 4. Conventional method of weapon firing (static targets) in open firing ranges is highly economical, since it can be undertaken without the need for any high-tech and expensive equipment/ infrastructure (Sabharwal et al, 2012; Talandová & Adámek, 2014). However, when it comes to imparting moving target training, it is pertinent to note that there are two distinct types of requirements that are required to be fulfilled, in order to be able to impart moving target training (Kirk, 2014; Toronto, 2011). Firstly, for each type of target motion to be generated physically, the electro-mechanical equipment/ mechanism is specific to that particular motion. For example, if three different types of target movements are required to be generated physically, it requires three different (independent) mechanisms, which cannot substitute for each other. Secondly, there is a need for three different firing ranges, one each for each of the three different (independent) mechanisms. This phenomenon can be clearly noticed in sports firing, where, different types of target movements are generated physically (ISSF, 2022). Imparting moving target training physically, thus entails, adequate physical area (non-inhabitant area) and associated infrastructure to generate different types of target motions. In this context, it is to be noted that,

the infrastructure required to generate moving target motion (physically) is relatively very highly expensive vis-à-vis static target infrastructure (Reddy & Garrett, 1995; Dutta, 1999).

Apart from physical (conventional) firing in firing ranges, firing training (both, static as well as moving target) can also be imparted through simulation technology, which has received great attention worldwide as an effective alternate training tool, for conventional methods. Simulation firing serves as an effective solution to compensate for various limitations such as paucity of adequate space for firing ranges, paucity of time, restrictions to conduct field exercises, avoid risk to life, etc (Dutta, 1999; Chauhan, 2013; Reddy & Garrett, 1995). However, a major impeding factor is that simulation method of training is highly capital intensive, by virtue of its sophisticated/ high-tech softwares and corresponding infrastructure associated with it. Well-developed countries such as USA, Russia, France, UK, etc, owing to their geographical conditions & constraints, as well as due to their technological advancements coupled with financial viability, use simulation methods extensively for weapon firing training, for both, individual as well as collective training (Dutta, 1999; Chauhan, 2013; Page & Smith, 1998). The advancements in computer & communication technologies coupled with the advent of extended applications of these technologies in the form of computer simulation models, computer wargames, etc, has made it possible to integrate simulation and live exercises through effective networking, thus making simulation, an effective training tool for military training (Chauhan, 2013; Page & Smith, 1998; Hodson, 2017). However, financial viability is definitely a challenging factor.

Thus, it is evident that, in the existing methods of training for moving target training, both, conventional methods (physical firing) as well as simulation methods are cost-centric. Hence, while developed (financially stronger) countries could always 'afford' to fulfil their training needs, either through physical methods or through simulation-based methods, most of the under-developed as well as developing countries, i.e., countries with (relatively) financially weaker economies, could not afford to do the same, understandably by virtue of budgetary constraints (Kirk, 2014; Toronto, 2011; Baloch et al, 2015). All such countries who did/ could not afford these expensive methods for moving target training, have resorted/ limited themselves to practicing firing of weapons, largely on static targets only, through conventional firing ranges (Sabharwal et al, 2012; Dutta, 1999; Talandová & Adámek, 2014). Thus, it can be construed that, owing to limitations to impart moving target training, the fighting forces of all such financially weaker countries are relatively less prepared to handle terror attacks (close-combat operations), by virtue of their lack of exposure to moving target training, and thus are considered more vulnerable.

### **1.7 Area of Interest: Firing skills on Moving Targets**

An analysis of terror attacks unleashed in the past reveals that, terror attacks can be broadly classified into two distinct categories. First, attacks, whose primary target is general public/ civilian population. The motive of attackers is to create mayhem and thus draw attention or prove/ establish their presence or dominance. London Bombings of 2005, Mumbai terror attacks of 2008, Paris attacks of 2015, etc are few of the examples of the first category, i.e., attacks targeting civilian population (Operation Black Tornado, 2018; FRANCE 24 English, 2021; SkyNews, 2015). The second category is, attacks with a pre-planned agenda to confront, specifically, the military or police. The confrontations between Security Forces and the

militants of ISIS or Taliban, in various countries (regions), Pathankot Airbase attack of 2016, Palestinian attacks on Israel Forces, etc, are some of the examples of second category, i.e., terror attacks specifically targeting security forces/ personnel (TESAT, 2022; Channel 4 News, 2017; wocomoHumanity, 2020; Real Stories, 2017; FRANCE 24 English, 2021; Pathankot Attack, 2020). It is pertinent to note that, in case of first category, i.e., when attacks are targeted at civilians, since the general public is un-armed, there is nil possibility of any kind of resistance to such attacks. Whereas, in case of second category, i.e., attacks on security forces (on patrol duties or check-post duties or combing operations, etc), there is a definite possibility that the soldiers can, and shall retaliate instantaneously. In such counter-terrorism operations (CT Ops), as explained earlier, the soldiers' efficiency (ability) to retaliate effectively, is significantly dependant on their firing skills on moving attackers (targets). In the same context (of effective retaliation), it is also pertinent to note that, in the initial days, when terror attacks were only a phenomenon of external threats, military soldiers were the sole agencies which used to handle such Counter-Terrorism Operations (CT Ops). However, ever since the terror attacks have propagated as internal disturbances also, i.e., within a country, ability of police personnel too, to counter / handle such attacks has gained significance, in terms of their weapon firing skills to fire accurately at attackers (Hosmer, 1990; Jha, 2009). In this context, it is pertinent to note that, as per conventional norms in most countries, police personnel are responsible to ensure internal peace whereas, soldiers (military forces) are responsible to ensure security from external threats (Gulati, 2012; Maheshwari, 2017; Jha, 2009). Thus, from the point of view of instant and effective retaliation to terror attacks by the security personnel of the first line of defence (soldiers as well as police), their weapon firing skills, in terms of their ability to 'fire accurately at moving targets (attackers)' is a key factor, which significantly influences the outcome of any such close combat CT Ops (Ramesh, 2012; Toomepuu, 1980; Badri-Maharaj, 2009; Maheshwari, 2017). It has also been earlier learnt that infrastructure and associated support facilities required for moving target training, is considerably expensive and hence is affordable only to rich/ developed countries (Dutta, 1999; Chauhan, 2013; Small Arms Range Design & Construction, 2011). Hence countries which cannot afford such huge infrastructure and budgets, must limit/ manage their training facilities with conventional methods only, i.e., in open firing ranges. It has also been established that firing ability on moving targets during training stage can be considered as a reasonable measure of ability to fire accurately at moving attackers in real-time attacks. In the backdrop of all these aspects, the area of interest of this research work is focussed on how to impart moving target firing training/skills through existing conventional firing ranges, so that it benefits front-line security personnel, i.e., the soldiers of first line of defence (soldiers as well as police), whose firing practice is largely dependent on physical firing only, in open firing ranges, and who do not have (adequate) access to simulation methods for firing practice on moving targets.

## **1.8 Detailed study of Existing Training Methods for Weapon Firing Training**

A study has been conducted amongst some of the security establishments in India, which impart weapon firing training to their respective trainees/ troops. The purpose of this study was to understand the existing method of imparting weapon firing training.

The pattern of training in all weapon training institutes has been observed to be similar at large, with minor variations, to suit respective local conditions and/ or organisational requirements/ motto. Initially, the trainees are imparted with theoretical knowledge on various

types of weapons, their characteristics, operational & maintenance specific instructions, and most importantly, significance of compliance to safe-norms/practices. General physical fitness training imparted to trainees as part of their routine curriculum, as such aids in their weapon handling ability. Trainees are also imparted with the knowledge of various types of firing ranges, specific features, and the various Standard Operating Procedures (SOPs) to be well-versed and complied with while conduct of a firing range. Firing range is a designated place to conduct firing practise. More details are covered in chap 2. Once the trainees are imparted with the requisite theoretical knowledge on weapon handling and safety norms, mock-drills are conducted in firing range to test the levels of assimilation of trainees, especially towards compliance of safety norms. Actual (practical) firing sessions are conducted ONLY to those trainees who have displayed satisfactory weapon-knowledge and safety-compliance.

Since most field stations/ units have open firing ranges, firing training (practicals) is initially imparted on static targets in these open firing ranges. Targets are kept at a distance of 25 yards from the firer, and the firer is required to shoot at targets from a designated 'firing position'. A standard Target is a thick brown paper (2mm Thick) of size 1x1 feet. It has four concentric circles, the details of which have been explained at chapter 2. At a bird's eye-view, when a target is shot, if the bullet hits the target near to its centre (i.e., towards the inner circle of the four concentric circles), a firer scores higher, as compared to, when the target is shot, away from centre. Nil score is assigned if the shot misses the target. Periodic assessments are conducted for trainees to assess the level of firing accuracy that they have learnt/ gained to shoot at static targets. The exact details of scoring methodology (vis-a-vis the four concentric circles of the target) have been explained in detail in chap 4. Based on the average of scores obtained by trainees, from various periodic assessments, trainees are broadly classified into four categories:

- (a) Marksmen:
- (b) Good grade Firers
- (c) Above Average Grade Firers
- (d) Below Average Grade Firers

The 'Below Average' Grade corresponds to those firers, who score less than 40%. It is important to note that, though the figure of 40% appears low, from the perspective of firing skill, it itself is a mentionable achievement. The whole focus of training is to enhance/ ensure firing skills of trainees to atleast 'Above Average' grade or above. It has been observed that, most weapon firing training institutes follow these norms quite meticulously. It has also been observed that most of these institutes have training facilities to impart firing training on static targets only. None of these institutes have moving target training facilities at ab-initio-training level. It was learnt that, moving target training schools are established separately, and that they cater for only few elite candidates, selected through a deep-selection process, from amongst various organisations, for the purpose of developing Special-Forces.

## **1.9 Feedback from Weapon Training Institutes through a Preliminary Survey**

The study to understand existing methods of weapon firing training was followed by a preliminary survey to obtain feedback from these institutes, about the efficacy of existing training methods vis-à-vis modern-day security needs, and their suggestions for improvement.

The intention of the survey was to obtain views of these establishments/ training institutes with respect to moving target firing, and its relevance at training stage.

For this, a set of fifteen questions have been prepared in the form of a questionnaire, seeking generic details in the form of feedback with respect to availability and need for training on moving target firing practice. This questionnaire was circulated amongst four training institutes: (i) Police Headquarters, Assam Police Training, Guwahati, (ii) BSF Headquarters, N-E Region, Guwahati, (iii) CRPF Head Quarters, NE Region, Guwahati and (iv) Army, Narangi Zone, Guwahati, Assam. The template of questionnaire is attached as Appendix 1. In all the feedbacks obtained, all institutes commonly opined that, moving target firing practice at training stage can play a significant role in improvising soldiers' firing skills, especially on moving targets and that this skill, in turn enhances their preparedness to effectively retaliate terror attacks.

### **1.10 Research Gap, Problem Statement & Hypothesis**

Literature review clearly brings out that modern days' security threats for many countries of the world is marked distinctly by the growing menace of suicide (fidayeen) styled attacks. When and where ever a terror attack is unleashed, the front-line foot soldiers, be it of the military or paramilitary or police personnel, deployed on patrol/ guard duties, are the first to bear the brunt of such terror attacks. A strong and significant deterrence to such attacks is the ability of front line of defence to successfully thwart such attacks or atleast give stiff resistance till the time the Special Forces can arrive and take-over the situation to neutralize the enemy. Hence, from the point of view of instantaneous and effective retaliation, ability of all front-line soldiers to 'fire accurately' at moving attackers (targets) is very crucial and hence considered as the most significant factor that determines the outcome of such CT operations. From the point of view of weapon firing training, ability to fire accurately at 'moving targets' during training/ practice sessions is considered equivalent to or a reasonable measure of soldiers' ability to fire accurately at 'moving attackers' in actual attacks. Hence, moving target training becomes highly essential/ desirous at training stage. It was also logically construed that, by virtue of the difficulties /limitations associated with generating different types of target movements physically, moving target training is not explored in this direction, i.e., firing training on moving targets using physical targets of movements is not undertaken. Further, preliminary survey of Indian weapon training institutions reveals that weapon training to trainees is imparted mostly in open firing ranges and that the primary focus is limited to imparting firing training on static targets only. The survey also revealed that firing training on moving targets is desirous to enhance soldiers' firing accuracy/ efficiency, in order to enhance their preparedness to tackle modern days' terror attacks more effectively, in terms of improved firing accuracy on moving attackers. Based on all these aspects, it can be said that a 'distinct gap' exists between the 'desired level of preparedness' vis-à-vis actual ability of front-line foot soldiers in handling modern day security threats (in terms of their ability to fire accurately at 'moving attackers/ targets). This phenomenon is more applicable to those countries (soldiers) who do not have access to moving target firing through expensive simulation softwares. To bridge this gap, (i.e., the gap between desired level of firing skills to fire at moving attackers/ targets and the firing skills acquired by virtue of practice only (mostly) on static targets), it is opined that there is a scope as well as need to explore feasibility to enhance firing ability/ accuracy of soldiers on moving targets, through requisite additional training, in order to

enhance their firing skills and in turn their preparedness to tackle modern days' security threats – terror attacks.

### **1.10.1 Hypothesis:**

Firing skills on moving targets can be significantly influenced (improved) by methodical training, which in turn is dependent on inherent learning skills of trainees, identified (expressed) in the form of their skill grade obtained while firing on static targets. Further, ability to fire at moving targets is inversely influenced by complexity of target movement.

### **1.11 Aim & Objectives**

In the backdrop of research gap identified, the aim of this research work is to design a suitable cost-effective training method to impart training and improve moving target firing skills, using a physical model, capable to generate various target motions physically, that can be used in open firing ranges.

The intended purpose for this design is to enhance the firing skills of soldiers (& police) on moving attackers (targets), thereby contributing to improve their overall preparedness to effectively retaliate any terror attacks and in turn enhance the deterrence value. This proposed method is considered more applicable to those countries who cannot afford existing expensive methods to impart moving target firing skills to their security forces.

The objectives are:

- (i) To explore various possible methods to impart / improve moving target firing skills through a physical model in a standard open firing range, and identify the most suitable & practical method, for the select conditions.
- (ii) To design and fabricate a working model for the suggested training methodology to impart moving target training
- (iii) To propose a training schedule to impart moving target training with the help of fabricated model.
- (iv) To design an assessment methodology to evaluate the extent of improvement in moving target firing skill, which is imparted through this proposed training methodology.
- (v) To conduct practical trials and validate the proposed methodology of training.

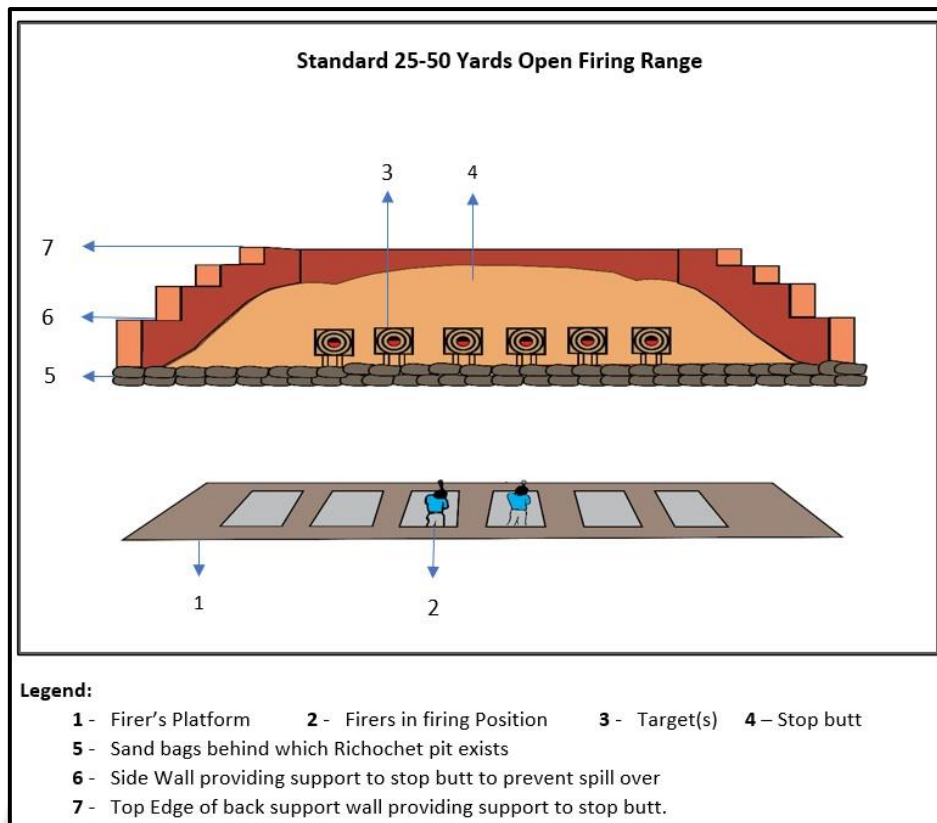
## CHAPTER 2: Exploration & Design Development of Training Method to Improve Firing Skills on Moving Targets

In this chapter, the sequential process followed to arrive at finalisation of design for prototype is discussed in detail. Before proceeding any further, it is first necessary, to obtain a broad overview of the way, weapon firing practice sessions are conducted in open firing ranges, the infrastructure requirements, the training environment, and various terminologies associated with weapon firing. This knowledge (an overview) is considered necessary, so as to appreciate the overall training context of weapon firing for soldiers as well as police, and the associated issues including practical constraints. Towards this, firstly, a detailed description of a Standard Open Firing Range of 25-50 yards is given below.

### 2.1 Salient Features of a Standard Open Firing Range

Open Firing Ranges are conventionally used to conduct weapon firing practice. Firing Ranges are generally of two types – 25 yards or 50 yards (Small Arms Range Design & Construction, 2011). The features of both types of ranges are similar except that the latter is larger in size. An open firing range, say of 50 yards, is a rectangular shaped plain ground open to sky, of the size 60 X 60 yards approximately. This open ground is specifically ear marked to conduct firing ranges and is generally located in such places, away from human habitation, so as to avoid any accidental injuries to any personnel during training/ firing sessions. Firing practice sessions are conducted strictly as per Standard Operating Procedures (SOPs), which are time tested as per certified standard norms (Small Arms Range Design & Construction, 2011; IAP-3901). These procedures have been refined and evolved over the years so as to ensure ‘zero’ chances of error in the conduct of weapon firing sessions and thus ensure nil injury or loss of life to any personnel, or damage to any property even by accident (Range Safety {MCO 3570.1C}, 2012; IAP 3901). A standard open firing range consists of three broad areas, Firing Point, Danger Area and Target Area.

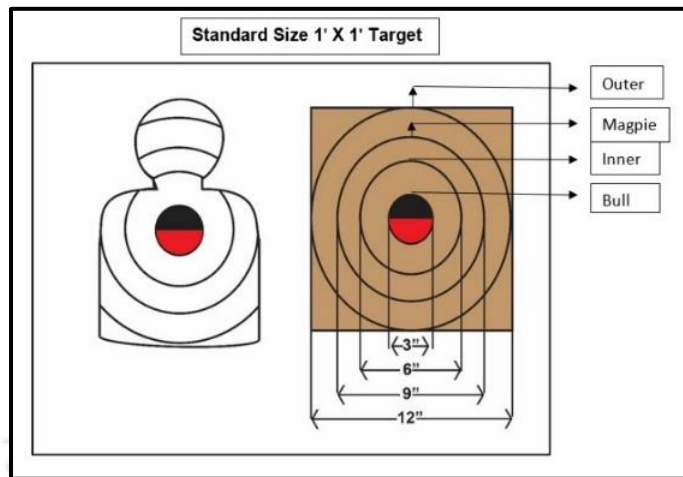
- (i) **Firing Point:** The firing point mainly consists of a workshop, a target store and a firing shelter for trainees/ personnel waiting to fire. The workshop is a place where targets are made ready (prepared), to be used in range. Target store is a place where ‘ready-to-use’ targets are kept in store. Both, the workshop as well as target store, are generally behind the firer’s platform which is shown in schematic Fig 2.1 below. A firing shelter or firer’s platform is an open flat ground with or without roof cover, where trainees (participants) are lined up in groups called details, to fire at targets placed in front of them, as per their turn. ‘Detail’ is the term referred to a group of firers who are earmarked to fire together for a particular training session. Depending on the size and other conditions of the range, a detail may consist of 4 to 6 firers. The schematic diagram of a standard firing range is depicted in Fig 2.1 below, with a firer’s platform consisting of six firing positions, as well as six targets, with each target corresponding to one firing position (firer).



**Figure 2.1 :** Standard 25-50 Yards Open Firing Range

- (ii) **Danger Area:** The danger area consists of stop butt and ricochet pits as shown in the above diagram (Fig 2.1). Stop butt is a huge mound of sand & saw-dust mixture. The purpose of stop butt is to absorb the pellets of fired bullets so as to avoid accidental travel of these pellets. These pellets, if not absorbed into the stop butt, can be a potential threat to life or may cause serious injuries to personnel or cause damage to property. The stop butt is supported by side walls on either side and a back support wall from behind. Ricochet, by definition is the motion of an object or projectile while rebounding or deflecting, one or more times from the surface over which it is passing or against which it hits a glancing blow. Ricochet pit is made available in firing ranges to prevent ricochet of pellets in case of accidental mis-fire, either too low or at a steep angle. Ricochet pit is a huge hollow pit dug in the area between firer's platform and targets placed behind sandbags. It lies between firer's platform and sandbags, closer towards the targets.
- (iii) **Target Area:** The target area consists of targets on which the shots are fired and a target trench. Target trench is dug deep, around 2½ -3 feet, behind the sand bags and in front of stop butt. This trench is used to hide oneself or place items useful / necessary to conduct firing, but which should not be visible from the firer's platform. A standard target is a square shaped 2mm thick cardboard paper, generally of size 1'x1' or in the shape of human bust of equivalent size. The targets are hanged on a suitable frame behind the target trench. Schematic sketch of a Standard Target is as shown in Fig 2.2 below.

A standard target consists of four concentric circles. The innermost circle is of 3 inches diameter (3" Ø) and is called 'Bull'. The other three bigger concentric circles are called as 'Inner' (6" Ø), 'Magpie' (9" Ø) and 'Outer' (12" Ø) respectively, in ascending order. A firer is graded for his firing skills depending on where his fired shot lands on the target. By broad understanding, a firer gains relatively higher score if he shoots at the inner most circle, (bull) as compared to his score when his shot lands on other bigger circles. And, a firer scores Nil if he misses the target completely. Firing is practised in various positions – sitting posture, lying down posture, standing posture, half-kneeled posture, etc. It needs to be noted that the performance of firer, i.e. ability to shoot at target may (shall) vary in different positions. Irrespective of position, period of regular practice is the key to improve one's firing skills. Hence, periodic weapon firing practice is highly essential to maintain skill currency.



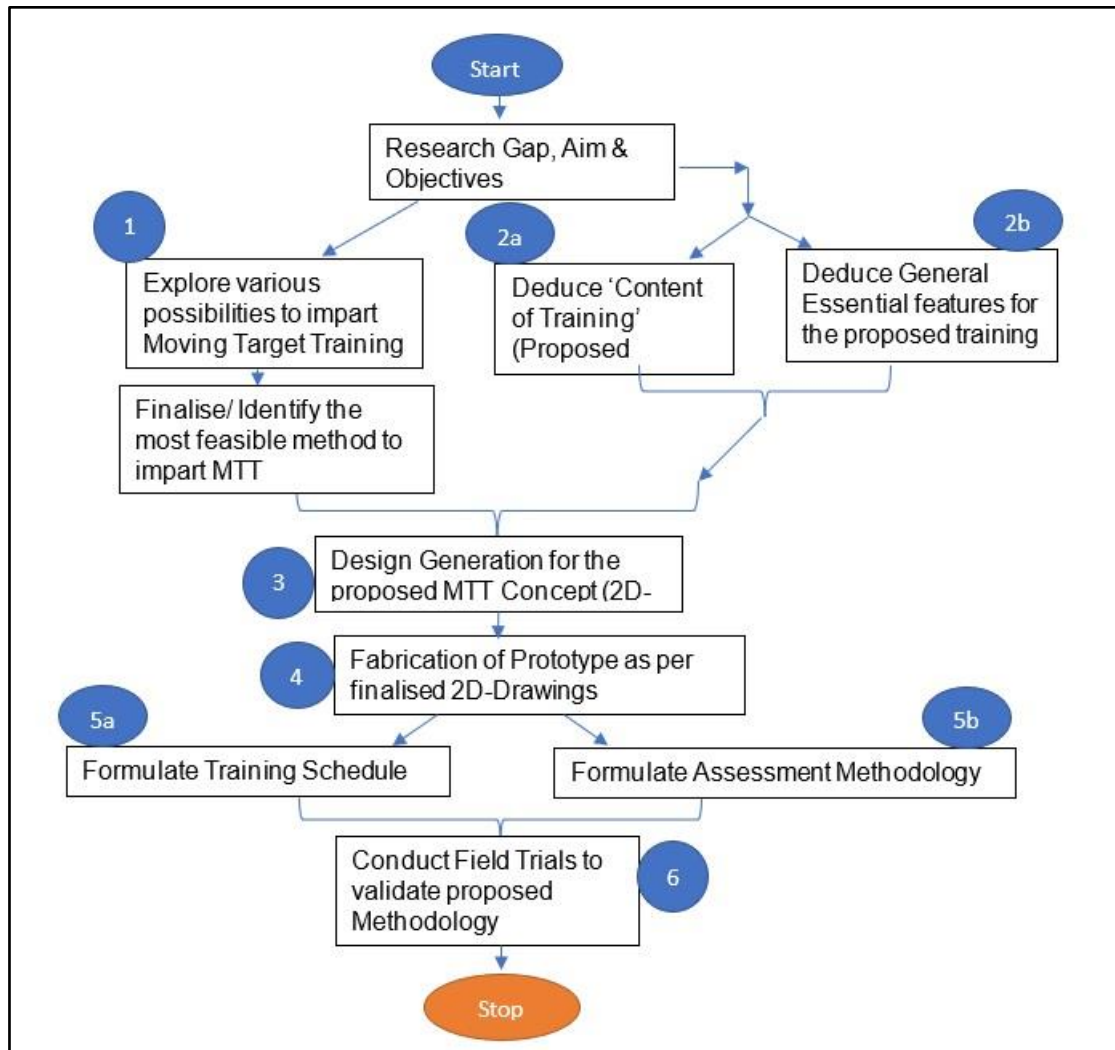
**Figure 2.2 : Standard Target of Size 1" X 1"**

### 2.1.1 Training Environment of Weapon Firing Training

An earmarked zone with requisite features as explained above is conventionally referred to as a standard open firing range, and is mandatory to conduct practical weapon firing sessions. It needs to be noted that all training institutions that impart weapon firing training, do have a firing range of their own. Apart from training institutions, most field stations also have independent firing ranges, to enable them conduct periodic (continuity) training to the personnel posted to respective field stations (Gimble et al, 1998; IAP 3901). Standard Operating Procedures (SOPs) are issued for all procedures and safety precautions associated with 'safe conduct' of Range (Range Safety {MCO 3570.1C}, 2012; IAP 3901). Strict adherence to these SOPs is mandatory to ensure Nil risk to either trainees or supervisors or support staff, while conduct of a firing range. Weapon firing training follows methodical training meticulously. Towards this, initially, the trainees are first imparted theoretical knowledge on various types of weapons used and their safe handling techniques. This is followed by imparting knowledge on clear understanding of various SOPs of firing range, safety precautions, target fixing & removal procedures, accounting of bullets fired and other associated subjects such as procedure to be followed in case weapon gets stuck while firing, emergency first-aid, etc. After imparting all requisite theoretical knowledge, the assimilation by trainees is tested to ascertain whether the trainees are well versed with all these procedures. The trainees shall then be permitted to gain hands on experience through practical firing sessions, only after ensuring that they have gained adequate theoretical knowledge necessary for safe conduct of firing sessions. Weapon firing, being highly risky & vulnerable, it is highly important that all precautions are followed at all times so as to ensure nil danger to any one's life or even injuries, that may occur in the process of weapon firing practice sessions.

## 2.2 Overview of Methodology

Literature review clearly brought out that distinct gap exists between the current firing skills of front-line soldiers of the first line of defence, on moving targets vis-a-vis desired level of firing skills on moving targets, especially for those soldiers (police included), whose training is mostly imparted on open firing ranges only. In the context that the front-line soldiers (first line of defence) are the first to bear the brunt in case of any terror attacks, the need for improved firing skills on moving targets has already been established in order to enhance their ‘security-preparedness’, to effectively retaliate such attacks. Accordingly, the aim of this research work and the objectives have been formulated. A broad overall sequence of the research work to fulfil various objectives is depicted in the form of a flow chart below:



**Figure 2.3 :** Flow Chart for overall sequence of the research work flow

### Note:

The above flow chart gives a broad overview of the methodology to achieve various objectives, as derived from the Aim of this research work. The same is depicted in a more detailed way, as a step-by-step process at each stage (phase), in the flow chart below. The flow chart below depicts various inter-related and contributing aspects in the overall work flow process.

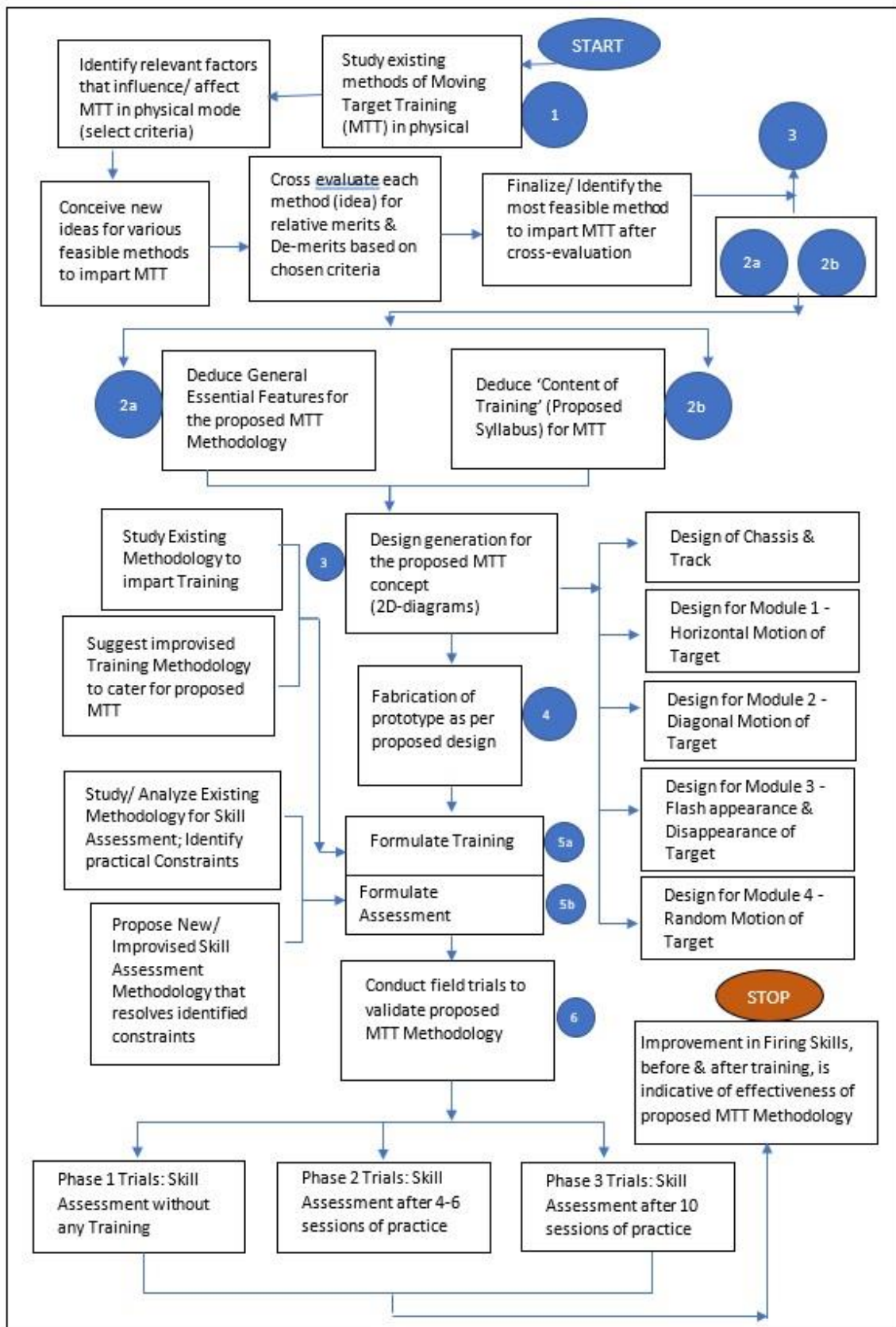


Figure 2.4 : Flow Chart depicting detailed work flow process

## **2.3 Detailed Description of Sequential Progress**

The flow charts above, give a comprehensive view of flow of research work, aimed to explore various possibilities, and identify the most suitable method to impart moving target training in open firing ranges. Initially, existing methods of imparting moving target firing are studied. Further, various factors that influence and affect the moving target training (MTT) requirement are identified. Subsequently, various new possibilities/ ideas to impart MTT through physical means, using an open firing range are conceived. These methods are then cross-evaluated against each other with reference to various factors identified, and accordingly, the most suitable method to impart MTT as per the select criteria/conditions is arrived at. Accordingly, a suitable design is generated and a model fabricated as per design. A suitable training schedule/ program is designed to impart MTT. Further, the existing skill assessment criteria is studied in detail. Based on the practical constraints in the existing criteria, an improvised skill evaluation methodology has also been designed to assess moving target firing skills. Lastly, a comprehensive plan to conduct field trials has also been worked-out, for evaluation of suitability of the model to impart MTT. Detailed description of each of these phases is as below:

### **2.3.1 Exploration of Existing Methods to impart Moving Target Training**

As mentioned earlier, firing training sessions are conventionally imparted in a 25-50 yards standard open firing range using physical targets and by actual (live) firing of weapons. Firing training is generally imparted collectively to a group of firers, commonly known as ‘detail’, which generally consists of a maximum of 4-6 firers (Range Safety [MCO 3570.1C], 2012; IAP-3901). Firing training can also be imparted in indoor firing ranges too, wherever available (Gimble et al, 1998). Further, firing training can be imparted virtually too using simulation technology in which a target is simulated on screen and the firer is made to fire at the target with or without using actual bullets (Bhagat et al, 2016). In the process of dwelling deeper to understand the fundamentals of moving target training (MTT), it was learnt that, at a very basic level, MTT is imparted with the help of a target which is made to move horizontally in either direction, using a traction force. This traction force to pull the target can be either by mechanical means or with the use of electric force (motor). Schematic diagram of this basic method of imparting MTT in which a firer is depicted as firing at a horizontally moving target mounted on a chassis is as shown in Fig 2.5 below. Even during the preliminary survey conducted, it was learnt that, some of the training institutes, impart moving target training on similar lines.



**Figure 2.5 :** Schematic representation of basic method of MTT

### **2.3.2 Factors considered relevant to impart Moving Target Training (MTT) through conventional (physical) methods**

The following factors and aspects are considered relevant to impart moving target training (MTT) by conventional methods, i.e., by physical means, in an open firing range. Each individual aspect/ factor is discussed in detail as below:

- (i) Conventional method of weapon training uses open firing ranges. Hence, if MTT is imparted using the same infrastructure, it shall result in huge savings on budgetary requirements, since it does not need any separate/ additional infrastructure to impart MTT. This aspect of feasibility to impart MTT in open firing range, and at low budget is highly significant for all under-developed and developing countries, where budget is an impeding factor to train soldiers (as well as police) on MTT using expensive, high-tech simulation softwares.
- (ii) Another important and significant advantage of imparting MTT using the existing infrastructure is that, since open firing range is a familiar training environment, it increases the chances of acceptability of the newly proposed system amongst the soldier-trainees. That is, they are not likely to feel that the proposed MTT as ‘alien’, owing to familiarity of learning environment. In this context, it is pertinent to note that ‘familiarity’ is one of the key factors for acceptance to learn / adapt to a new concept (Gass & Varonis, 1984; Hackbarth et al, 2010).
- (iii) Another important factor is that, in a shooting range, from the firer’s perspective, ideally, nothing should be visible in the target area, except for the target (Small Arms Range Design & Construction, 2011; Range Safety [MCO 3570.1C], 2012; IAP-3901). The purpose is to ensure full focus of the firer, on to the target only. In other words, the purpose is to ensure nil deviation of firer’s focus due to the presence of any other object or item (other than the target) in the target area. The underlying reason for this is that, this also ensures that no other item or equipment is damaged by a bullet fired, even by accidental firing (wrong aim of firer). In this context, it is very important that the

proposed training mechanism for MTT should be designed in such a way that except for the target, it has no other signature/ visibility in the firing area. That is, ideally, except for the target, nothing else should be visible to the firer. It also entails that the firers should preferably possess 'certain minimum skill level of firing', so as to prevent accidental damage to the moving target mechanism/ structure by unskilled firing.

- (iv) For any country, it is a fact that soldiers as well as police, are by default, deployed in various field stations, spread across the geography of that particular country. Considering this fact, it is logical to construe that the proposed MTT model should be implementable in all locations, spread across the geography of a country, so that, it succeeds in imparting MTT without the need for the troops to be shifted / taken to a 'particular' location/ station where MTT facility exists. In other words, the proposed MTT model should be 'accessible' to all, even to those working in far-flung or remote locations. This feature saves huge budget in terms of avoiding two types of expenses. First, the expenses associated with shifting/ transferring of troops to a station where MTT facility exists (& back on completion of training). Second, the expenses associated to maintain additional troops at every field station, to be used in place of those, who are to be withdrawn to impart training on MTT.
- (v) Weapon firing skill, being a specialist skill, needs periodic practice, to hone & maintain the 'skill-level'. Towards this, all troops (soldiers as well as police) are imparted periodic training through out the year, to maintain their currency of skill and to improve even further. Hence, the proposed MTT model/ methodology, since is proposed to be used in open firing range, shall be exposed to weather vagaries throughout the year. Hence, it is preferable that the proposed MTT methodology has certain characteristics such as all-weather operability, ruggedness, ease of maintenance, etc.

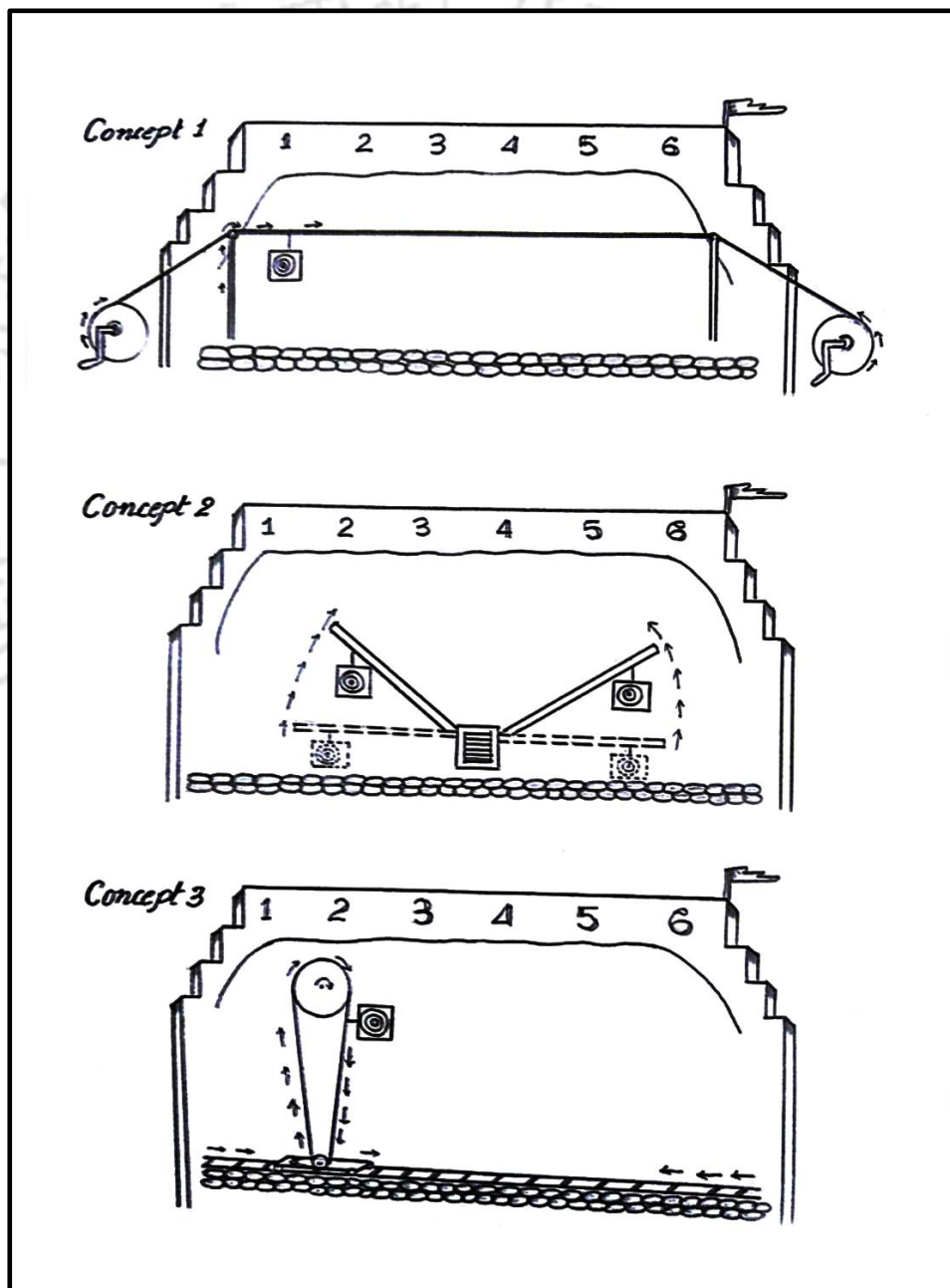
### 2.3.3 Conceptualisation of various ideas/ Feasible Methods to impart MTT

Moving target training (MTT) encompasses firing training on targets which are made to move in different directions with the help of suitable mechanisms. With the premise that the proposed MTT system is required to function in existing infrastructure (open firing ranges), available at field stations, the following concepts have been innovatively conceived to generate target motions for imparting MTT:

- (i) **Concept 1: Target Motion by Pulley Mechanism.** The first idea is inspired by the concept of drawing water from a well, with the help of rope & pulley. This concept, has been innovatively conceived in horizontal direction instead of the conventional vertical direction. That is, let there be a long rope tied across the range, running over two different pulleys, one each on either ends of the range. Let the targets be hanged by a suitable mechanism to this rope. If the rope is moved to roll over the pulleys, the targets automatically move along with the rope. The force required to pull the rope can be a mechanical means or a motorised force. Schematic sketch of the concept is shown in fig 2.6 below. A few limitations of this idea/ concept are as mentioned below:
  - (a) The target can move in horizontal direction only. It cannot move in any other direction. This feature limits the scope of training.
  - (b) The average width of a standard range is approx 50 ft. Thus, owing to this long length of rope which covers the entire width of the firing range, midway drop of the rope is unavoidable. This shall definitely lead to difficulty in the movement of the target from one end to the other. The other challenge is that, due to this

midway drop of the rope, the target shall always have a tendency to accelerate towards the midway drop point, which naturally is the lowest point in the entire travel. This feature thus cannot ensure uniform motion of target nor can the speed of target be varied/ controlled.

- (c) From the firer's point of view, the mere presence of rope running across the width of a firing range, in itself is a 'distraction', since it is always visible in the target area. Thus, it serves as a potential obstacle, likely to be hit / damaged by accidental/ wrongly-aimed firing. Further, the rope is most likely to oscillate (move up & down) when the target moves from one end to the other. This shall make the rope even more 'distractive' and thus becomes even more vulnerable to be hit by a fired bullet.



**Figure 2.6 :** Schematic sketches of three Innovative concepts to impart MTT

(ii) **Concept 2: Target Motion by Cantilever Mechanism.** The second idea is inspired by the barricade system generally seen at every toll gate on any highway. In all such systems, the barricade is free on one end and is pivoted to a cantilever mechanism to a solid structure on the other end. The barricade can be raised or lowered, as and when required, with the help of a rope or suitable mechanism from the pivoted end. The new idea is conceived on similar lines, i.e., to move the targets in the range, with the help of barricade like cantilever system. Let two such mechanisms/ systems be installed at the centre of the target-area of the range, back-to-back. Each of the mechanisms operate one barricade each. Two such systems are employed because, construction wise, a single length of barricade to cover the entire width of range (50 ft approx) shall be more challenging, vis-à-vis two systems, arranged back-to-back, each covering half the width of range. Schematic sketch of the concept is shown in fig 2.6 above. Initially, the target is attached to the free end of barricade through a suitable mechanism so that it can slide along the barricade. As the barricade mechanism is operated (raised), the target slides along the barricade towards the pivoted end. The target can once again be brought back to its original position by lowering the barricade (reverse motion) with the help of suitable mechanism. During the initial setup, adequate care/ attention needs to be taken to setup the height of the target in such a way that the target is always well within the safe firing zone of the target area. Following are some of the limitations of this idea/ concept:

- (a) The barricade as well as the pivoted end-structure, both, shall be major distractions in the firing zone (target area) and hence are highly vulnerable for damage. Further, in this case, since the size & area of exposure being quite big as compared to concept 1, the probability of accidental damage also is even higher.
- (b) Target can automatically slide along the barricade, only in one direction, i.e., when the barricade is raised. To bring back the target to its original position, a suitable mechanism needs to be employed. This poses a limitation that firing can be done only during one side of target travel. In other words, after every single operation of barricade, firing has to be stopped, to facilitate 're-set' of the target to its original position. This feature is likely to adversely affect the focus of the firer.
- (c) The rate of target travel is not uniform. This is because of the fact that once motion of the target is initiated, the target accelerates towards the pivoted end due to gravity and hence the rate of target travel is not uniform nor can be controlled.

(iii) **Concept 3: Target Motion by Traction Mechanism.**

In this concept, the target is conceived to be mounted on a chassis with an appropriate superstructure. The chassis can be moved on either direction with the help of a motor which can provide traction force. Target moves along with the chassis. Various types of target motions can be achieved by employing suitable mechanisms and associated superstructures. Schematic sketch of the concept is shown in fig 2.6 above. Limitation of this concept, as common to other concepts is that, the exposed portion of mechanism/ superstructure is vulnerable to damage by accidental mis-fire. Otherwise, some of the major advantages of this concept are:

- (a) Different types of target motions can be achieved.
- (b) Firing practice can be continued without any hindrance since target can move along with chassis on either side without any intervention.

(c) Rate of target travel can be controlled.

(iv) **Concept 4: Target Simulation through Laser Technology.**

In this concept, the target is conceived to be simulated (created) with the help of Laser beam Technology. The target is created on the sand mound, above the stop butt or on a screen in the target area, which is specially erected for the purpose. Firers are made to fire at this illuminated target. The advantages & disadvantages of this concept are as listed:

Advantages:

- (a) Firing zone is free of any obstacles or items associated to generate target motion. Hence NIL disturbance to firer's focus.
- (b) Any type of target motion can be generated due to the inherent advantage of laser technology.

Limitations:

- (a) Laser images appear distinctly in darkness, but not in broad daylight. Hence not suitable for open air firing ranges.
- (b) Relatively more expensive as compared to a physical model.
- (c) Dependence on 'technical know-how' to maintain the system.

**2.3.3.1 Finalising the most feasible method to impart MTT by cross-evaluation of various concepts**

The newly conceived ideas/ methods to impart moving target training (MTT) have been evaluated against the set of factors considered relevant to impart MTT in conventional methods – in open firing ranges. These factors chosen for cross-evaluation have already been discussed in detail and listed at para 2.3.2 above. From this cross-evaluation of the relative merits & demerits of each of the ideas conceived, it is very evident that 'concept-3', i.e., Traction Method, stands out to be most suitable choice for imparting moving target training. The summary of cross-evaluation carried out is listed in table 2.1 below. Only for the purpose of cross-evaluation, MTT by virtual simulation has also been carried out.

**Table 2.1 :** Cross-Evaluation of various available options against Reference Criteria

<b>Evaluation Criteria</b>	<b>Concept 1 (Pulley)</b>	<b>Concept 2 (Cantilever)</b>	<b>Concept 3 (Traction)</b>	<b>Concept 4 (Laser)</b>	<b>Simulation (Software Based)</b>
Feasibility to impart MTT in open firing range	Yes	Yes	Yes	No	No
Feasibility to generate different types of target motions	No	No	Yes	Yes	Yes
Feasibility to impart MTT at Field Stations	Yes	Yes	Yes	No	No
Rough Weather Operation	Yes	Yes	Yes	No	No
Need for Additional Infrastructure	No	No	No	Yes	Yes
Dependence on high-technology or costly/complx spares	No	No	No	Yes	Yes

Control on target motion / travel rate	Yes	No	Yes	Yes	Yes
Feel of Reality	Yes	Yes	Yes	Yes	No
Ease of Operation	Yes	No	Yes	Yes	Yes
Ease of field level repairs/ maintenance	Yes	Yes	Yes	No	No
Ease of spares availability	Easily available	Easily available	Easily available	Not easy	Not easy
Ruggedness to bear weather vagaries	Yes	Yes	Yes	Relatively Vulnerable	Highly Vulnerable
Overall Cost	Low	Low	Low	Relatively High	High
Overall degree of acceptability by trainees owing to familiarity	High	High	High	High	Low
<b>Overall Suitability</b>	No	No	<b>Yes</b>	No	No

From the analysis as reflected in above table, a physical model (concept 3- traction method), has been identified as the most suitable and feasible method to impart moving target training (MTT) using open firing ranges.

#### 2.3.4 Identification of essential features for the proposed Traction Model of MTT

Earlier, at para 2.3.2, certain factors considered highly relevant for imparting MTT on open firing ranges have been mentioned. Based on these factors as criteria, various newly conceived ideas have been cross-evaluated against each other, for their relative merits & de-merits. In the process, 'Traction Method' evolved as the most suitable method to impart MTT. The following aspects are also considered as relevant, in addition to the above-mentioned factors (of para 2.3.2), which need to be considered while designing a suitable working model to impart training through traction method.

- (i) MTT is proposed/ expected to be imparted in existing open firing ranges. It is to be noted that existing firing ranges across various field stations are as such regularly utilised to impart periodic training on static target firing, to all troops (soldiers or police) of that particular station. In this context, it is very significant to note that, in the proposed design for MTT, the model should be so designed that, on completion of imparting MTT, the model (or its accessories/ parts) should not be visible in the target area when the range is offered for static firing. This entails that, the proposed MTT model, preferably be a modular construction, so that, when required, it can be assembled at the range, and after job completion, it is dismantled and stored safely so that MTT model or its' parts do not become obstacles/ hindrances to conduct static firing.
- (ii) Continuing on the same lines above, MTT model should preferably be easy for quick assembly as well as for dis-assembly. This feature aids to economy of effort. Also, it is preferable that the model is user-friendly too, and easy to operate, i.e., does not require any complex tools or mechanisms to operate.
- (iii) Since a Chassis model is envisaged to impart MTT by traction, a sturdy track shall be required for the chassis to move smoothly. A track is preferred to move chassis rather than to move it on the ground for two reasons:
  - (a) Movement on track shall be smooth as compared to that on soil/ ground.
  - (b) If chassis moves on ground, the support mechanisms to facilitate traction such as pull-push rope, coupling devices, motors, pulley etc are very close to ground level

and hence shall be subjected to severe dust or grass or small pebbles ingestion and associated maintenance issues. However, if the chassis moves on a track, at a reasonable height above ground, all such issues and associated maintenance problems are automatically addressed (avoided).

- (iv) Since it is envisaged that the proposed MTT model is preferably modular in construction, various sub-assemblies that form a part of MTT, should have ‘quick-release mechanism’ sort of joints to facilitate quick assembly or dis-assembly. Ideally, all the mechanisms/ sub-assemblies should be simple in construction, yet rugged/ sturdy. They should be fabricated with easily available commercial spares, (i.e., not dependent on custom designed specific spares), to cut down on cost of fabrication. Further, any necessary repairs / replacements of all such mechanisms/ sub-assemblies should preferably be do-able at field station level itself and thus reduce down-time.
- (v) Factors/ aspects discussed earlier at para 2.3.2 are, as such required to be taken into consideration.

### **2.3.5 Deduce ‘Content of Training’ (Proposed Syllabus) for MTT**

The purpose of proposed moving target training (MTT) is to enhance moving target firing skills of all front-line foot soldiers (police included) of the first line of defence, especially of those, who do not have access/ exposure to MTT through simulation models. The proposed MTT aims to enhance the firing skills of combat troops (soldiers as well as police) on moving targets, so that, they are capable to shoot accurately at moving attackers in case of actual attacks and thus counter/ thwart such surprise enemy attacks more effectively. Hence, in order to formulate the ‘content of training’, it is necessary to understand the actual ways or methods of attackers’ movements in such attacks (real attacks), so that this knowledge can serve as a reference guide line to prepare troops adequately to counter such attacks more effectively in future. That is, if adequate knowledge is gained about pattern of movements of attackers during attacks, then, such knowledge can be used as a reference guideline, to formulate the ‘training content’ in terms of the quantum/ type of firing skills required for the troops of first line of defence, to be able to handle such threats more effectively in future. This can be effectively termed as ‘proposed syllabus for moving target training’. Towards this, as a first step, data with respect to various terror attacks globally, unleashed in the past 15-20 years has been gathered for analysis. In the process, it was learnt that very limited data was available in published journal articles or conference proceedings. Hence, data from open media sources such as analytical reports published by established media houses, interviews & anecdotes of live / primary witnesses, recorded videos of the live attacks and simulated versions with theoretical analysis reports prepared by analysts have also been studied. Data collated from open sources included news articles published/ broadcasted by global channels such as EuroNews, SkyNews, Channel 4 News, France24English, etc as well as Indian origin News channels/ broadcasters such as The Hindu, Times of India, Hindustan Times, The Quint, Tribune, etc. Few of the references surfed are mentioned here for ready reference (EuroNews, 2016; FRANCE 24 English, 2021; SkyNews, 2015; Channel 4 News, 2017; wocomoHumanity, 2020; Real Stories, 2017; FRANCE 24 English, 2021; Rawat, 2019; Ahlawat, 2018; The worst Maoist attacks in the last 10 years, 2017; Deadliest attacks on security forces in India, 2016; Manoharan, 2013; Dhaliwal, 2016; Siyech, 2019; The Times of India: Chhattisgarh Maoist attack, 2021; Srivastav, 2009)

After initial segregation and grouping of data, event (attack) wise, cross references and correlations of various versions of same event was used as the principle method to re-construct

and re-verify the authenticity of broadcasted version to that of actual reality. This was done to the extent feasible, where ever multiple versions of same event were available for analysis. During this analysis, it was noticed that, since many attacks were suicide styled, there was neither any hesitation nor any fear of death in the movements of attackers, especially while approaching for the attack. The point that is highlighted is that, the attackers seemed to have been psyched to extreme levels that, they were not found hesitating to even sacrifice their life in their strong pursuit to execute the attack. It was also observed that, the attacks were unleashed with such high precision and a big element of surprise that, the reaction time available for security forces to retaliate was so much less(er). After having thoroughly analysed all available data event wise, the following common pattern has been observed in the movements of attackers in various terror attacks unleashed in the past:

- (i) The attackers approached the selected area of attack, generally in a vehicle, or even by walk/ run, to ram their way through the point selected. The approach path followed is generally the road/ path leading to the chosen attack point. In few other cases, the attackers hid/ camouflaged themselves in surrounding bushes and suddenly pounced on the patrol party, unleashing ghastly attack. In all such cases, the attackers are observed to have approached in a (horizontal) straight path in most unexpected situations and in unbelievably high speeds, leaving almost zero time to react. Thus, from the point of view of retaliation, security forces are required to fire at the attackers instantly, approaching them straight or at an angle (in the same horizontal plane). From the training point of view, this skill can be considered equivalent to, the ability to of soldiers to fire at horizontally moving targets.
- (ii) Another pattern observed is that, in a given situation, the attackers have positioned themselves safely (hided safely) in some area in the vicinity, waiting for the right time to attack as per plan. But, before the attack, when such (likely) attackers are faced with resistance, i.e., when challenged to prove their identity because of suspicious movements, etc, the attackers were observed to escape from that point at lightning speed using some staircase nearby or by sliding down along a rope or a ramp or whatever means available at that point. In such patterns, it could be observed that the attackers followed a slant or diagonal path to escape. In other words, from the training point of view, the soldiers were required to fire at attackers (targets) moving in slant direction (diagonally).
- (iii) In another pattern, in few cases, especially in combing or counter-offensive operations, where the security forces could get an opportunity to open fire at the hiding attackers, the attackers were observed to use opaque objects such as trees, cars, big boulders, etc as shields to protect themselves as they planned their escape from that spot, and vanish away. Thus, the security forces could fire at the attackers only in such short spans of time when the attackers were visible, while moving from one obstacle to another, in their process to escape, or at times, to just duck and await escape opportunities. In this pattern, the need to fire instantly as well as accurately at the enemy (target), as and when they/ it appears, (like a flash) was noticed. This, from the training point of view, soldiers were required to fire accurately as and when the enemy (target) appeared momentarily, for a very small fraction of time, like a flash.
- (iv) In another pattern, after a successful attack, (eg: after ambush operation on patrol guards in a forest or remote area, etc), the attackers were observed to escape in multiple directions. Thus, security forces were required to fire at these escaping attackers in different directions simultaneously. In such cases, the security forces were required to

fire in different directions at different attackers, who ever could be sighted/ shot at, with an aim to nail him/ them down. That is, the security forces were required to frequently change their aim from one attacker to another attacker, yet be adequately skilled, to fire at those attackers accurately. From training point of view, this skill can be considered equivalent to ability to shoot accurately at randomly moving targets.

From the above analysis, it was thus deduced that, moving target training (MTT) is to be imparted, fundamentally on four different types of target motions as mentioned below:

- (a) Horizontal motion of target
- (b) Slant or Diagonal motion of target
- (c) Flash Appearance & Dis-appearance of Target
- (d) Random motion of target

This is the broad outline of syllabus formulated for MTT (content of Training). The details of design formulation and finalisation to fabricate a prototype model to impart this training is discussed in subsequent paragraphs.

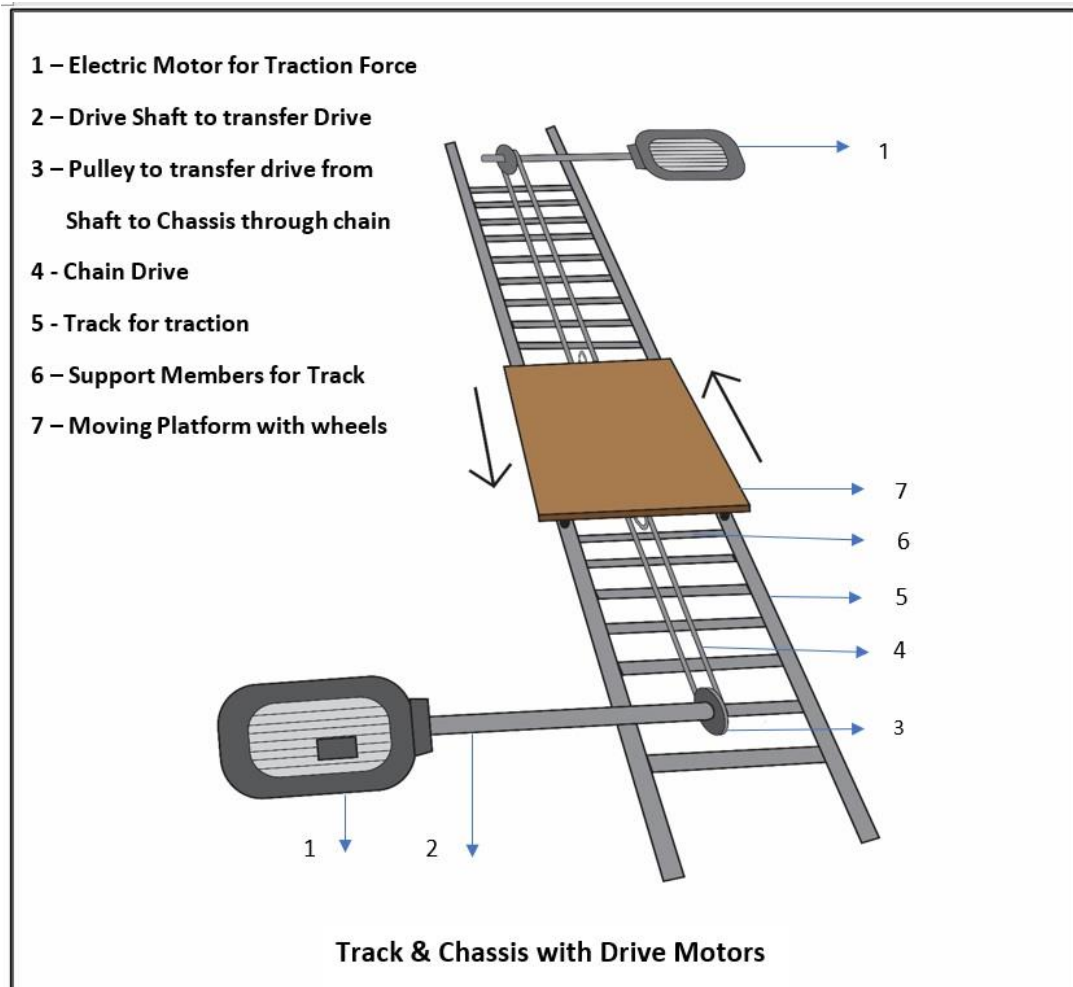
### **2.3.6 Detailed Design (Drawings) of Chosen Concept -Traction Method**

From the analysis of various relevant factors, it has earlier been deduced that a physical model (not simulation software) is the most suitable model, to impart moving target training (MTT) in already existing ranges at field stations. Further, from the analysis of various actual attacks, the content of training for MTT has also been deduced, to impart training on four different types of motions. The design of this proposed model, is thus conceived as a chassis, movable on a track by traction force, capable to carry/ hold four independent modules, one at a time. Each module is capable to generate one particular type of target motion. Thus, the chassis with the help of four independent modules is conceived to impart training on four different types of target motions – horizontal, slant, flash & random motions. Since it is a physical model, all these four types of motions are required to be generated physically, and NOT by computer simulation. This aspect is highlighted in the context that, generating different types of target motions physically, through electro-mechanical means, for the slant motion, the random motion of target as well as flash appearance & dis-appearance of target, that too on a moving chassis, is a challenge in itself.

#### **2.3.6.1 Design of Chassis & Track**

The chassis, a moving platform with four wheels, is conceived to move on a custom-designed track. The track is specially designed to facilitate smooth chassis motion. Four independent modules are conceived, each mountable on this chassis with the help of suitable superstructure, one, at a time. Two electric motors are planned to provide the driving force (traction), required to move the chassis along with its mounted superstructure(s) in both directions. The driving force of electric motors is transferred to chassis with the help of suitable drive transfer mechanism consisting of a drive shaft, metal rope and suitable pulleys. The average width of a firing range, designated for firing, i.e., where firing can be carried out, is approximately 60 ft. Hence, the length of track is conceived to be 10ft more, i.e. approximately 70 ft, such that it is around 5-6 ft extra on both sides of the width. This facilitates the chassis to move/ run along the entire width of range, from one end to the other, so that, the entire width of firing range (60 ft) can be utilised for firing practice. The additional 5-6 ft length of track on either side of the firing range helps in safe parking of the chassis at either end, away from the sight/ visibility of firing zone. This feature, thus aids in preventing its accidental damage to chassis & its superstructure when not in use, especially when static firing or some other practice is going on in the same range. The track is strengthened by adequate support members, to make it sturdy,

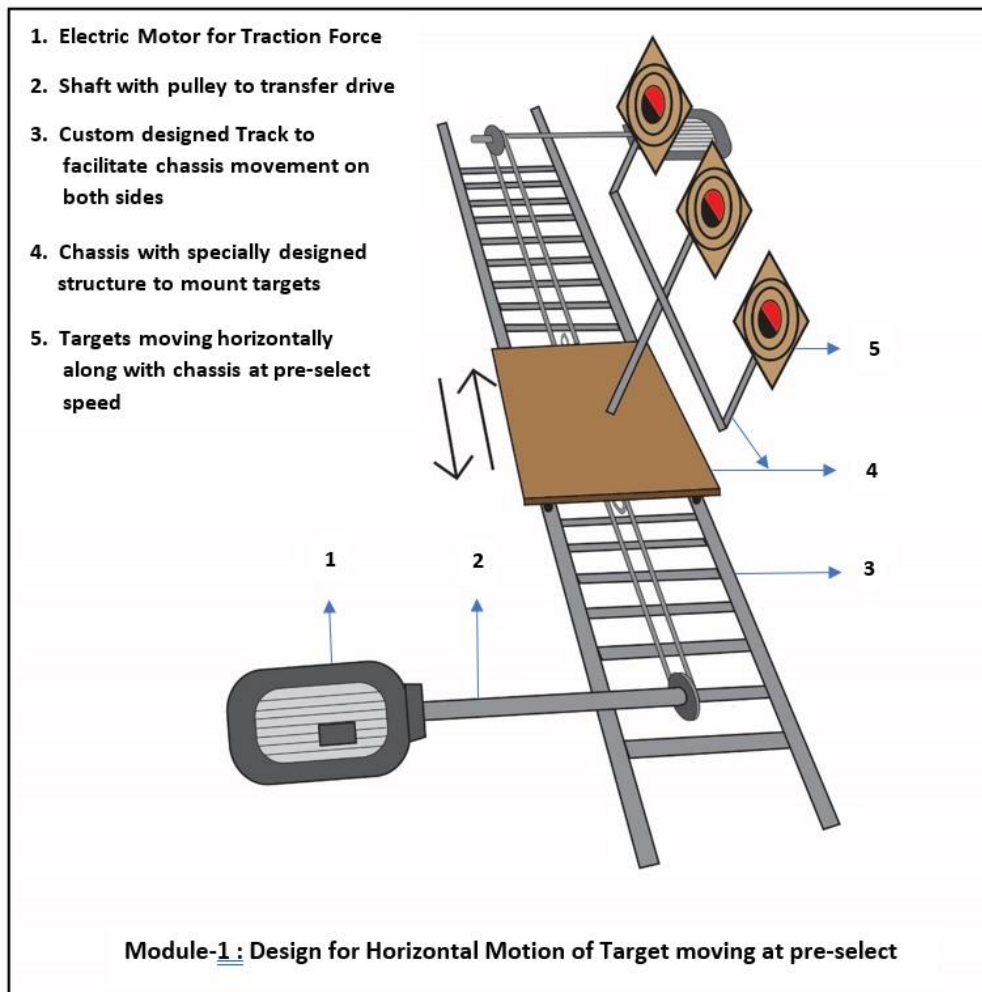
to facilitate smooth motion of chassis over it. Schematic diagram (2D- drawing) of the proposed design is as shown in fig 2.7 below:



**Figure 2.7 :** Schematic Design of Track & Chassis

### 2.3.6.2 Design for Module 1: Horizontal Motion of Target

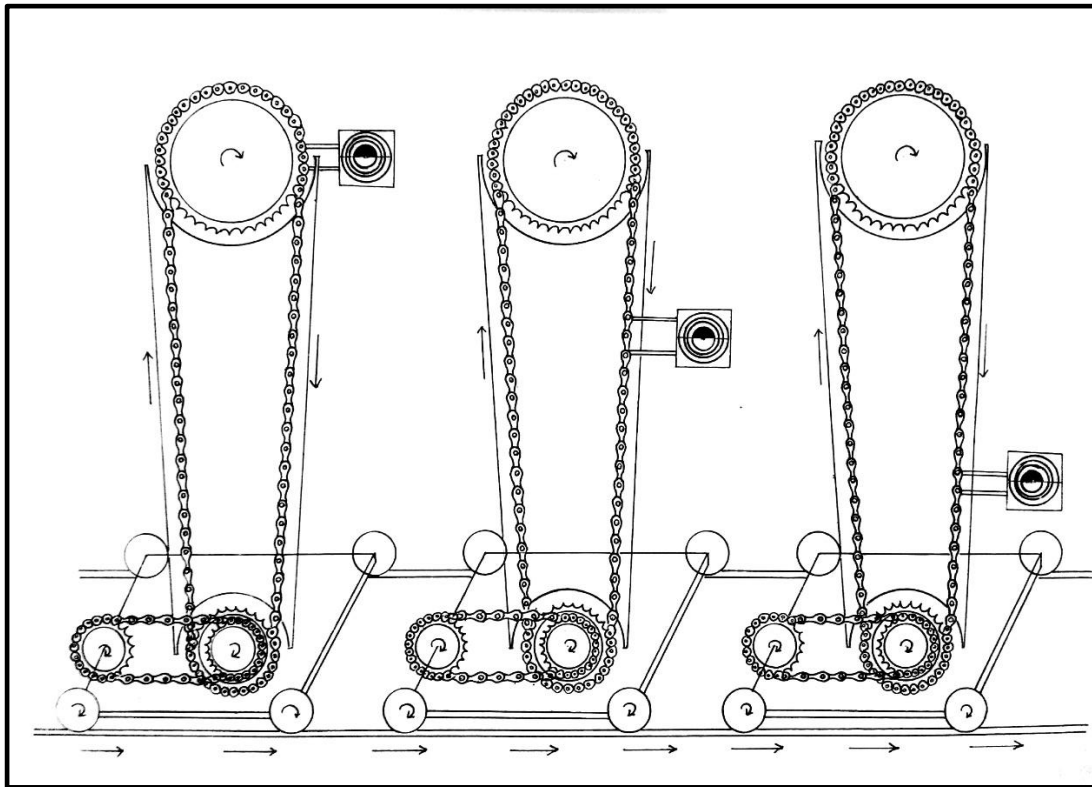
The design for Module 1 (Mod 1), to generate horizontal motion of target, is conceived to have a superstructure with a provision to hold three targets at a time. This superstructure is conceived to be mountable on the chassis with the help of suitable lock-mechanism. Whenever the chassis moves, the targets also move along with the chassis, resulting in horizontal motion of the targets. In this concept, three firers can be made to practice at a time, one firer on each target. Schematic sketch (2D- drawing) of the proposed system is as shown in Fig 2.8 below:



**Figure 2.8 :** Design for Module 1: Horizontal Motion of Target

### 2.3.6.3 Design for Module 2: Diagonal (Slant) Motion of Target

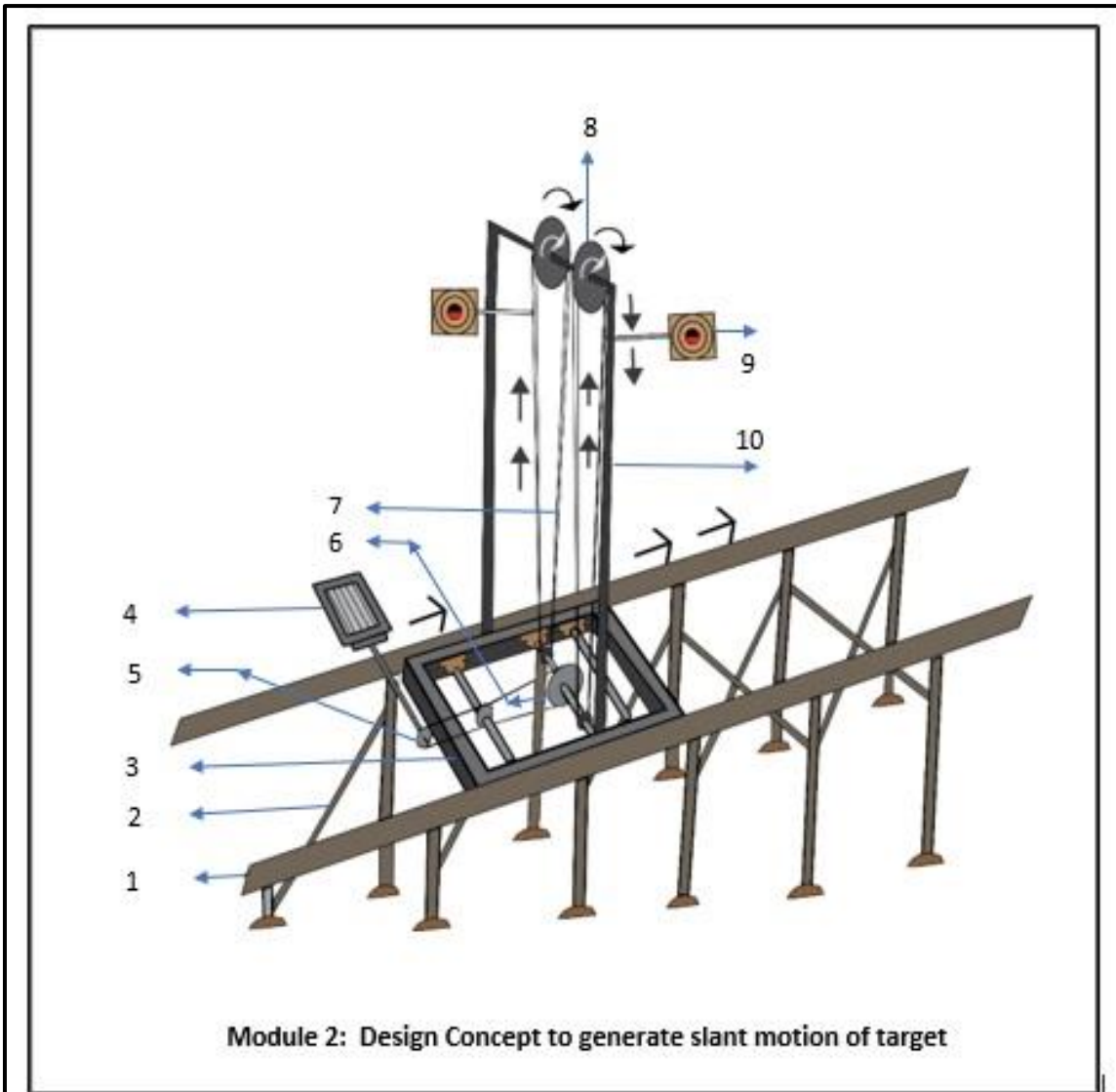
In the concept of Module 2 (Mod 2) for slant motion of the target, when the chassis moves horizontally, the target, mounted on a superstructure, shall move vertically. This combined resultant effect, i.e., the combination of vertical motion of target coupled with horizontal motion of chassis results in ‘slant’ or ‘diagonal’ motion of the target. In this module, a custom designed drive transfer mechanism is conceived which converts horizontal motion of chassis into vertical motion of target. Targets are attached to the belt/ chain used to transfer the drive. In this mechanism, as the chassis moves horizontally, the target correspondingly moves vertically. The resultant effect of this simultaneous motions of chassis & target results in the ‘slant’ or ‘diagonal’ motion of the target, when viewed from the firer’s point (firing range). Schematic sketch of the drive transfer mechanism is as shown in Fig 2.9 below.



**Figure 2.9 :** Schematic sketch of Horizontal to Vertical Drive Transfer Mechanism

As can be seen in the picture above, while the chassis moves horizontally from left to right, the drive transfer mechanism causes the target to move vertically from up to down. The simultaneous combined motion results in slant or diagonal motion of target. To house this entire mechanism, an ‘inverted-U-shaped’ structure (II) is conceived. The size of gears / pulleys are selectively chosen to obtain a speed reduction ratio of 1:6. Thus, when the chassis covers the entire width of the range, i.e., approx 60 ft, then, the targets shall vertically move by 10 feet. Thus, the height of II- structure to house this mechanism is thus deduced to be around 12 feet, to suit the speed reduction gear ratio.

In the conceived design, two drive belts/chains are used to transfer the drive. Two targets are attached, one each to one belt/ chain drive. The two targets are attached in such a way that they are made to move in opposite directions, i.e., as the chassis moves horizontally, one target travels in upward direction, (from bottom to top), whereas, the other target moves in downward direction, (from top to bottom). Since two targets are available, two firers can be made to practice simultaneously, one on each target. During the initial / ground-work trials, it was observed that, the targets ‘sway’ continuously while moving in slant motion. This reduces the visibility of target (to fire), when viewed from firer’s point. To overcome this hurdle, a target-guide mechanism was also conceived, to ‘guide’ the path of target travel. This mechanism was incorporated to ensure that target is always visible to firer while moving along with chassis and does not go out of sight due to swaying. Schematic sketch of the conceived design (2D-drawing) is shown in Fig 2.10 below.



**Legend**

- 1 – Track for traction of chassis    2 – Support Structure for Track    3 – Chassis with four wheels
- 4 – Electric Motor for Drive    5 – Driver Pulley for motion transfer from Motor (4) to Chassis (3)
- 6 – Twin action Pulley; Gets 'driven' by pulley 5 due to horizontal motion of Chassis; At the same time, serves as 'Driver Pulley' to convert horizontal motion into vertical motion
- 7 – Belt Drive which transfers motion from twin action pulley (6) to driven pulley on upper shaft (8)  
Belt drive rotates on these two pulleys, i.e 6 & 7
- 8 – Upper shaft with driven pulleys    9 – Targets mounted on drive belts (7)
- 10 – Specially designed support structure to house upper shaft & pulleys (8) and to ensure steady motion of target without flipping or turning while moving.

**Figure 2.10 :** Design for Module 2: Slant (Diagonal) Motion of Target

#### 2.3.6.4 Design for Module 3: Flash Appearance & Dis-appearance of Target

The concept for module 3 (Mod 3) is to make the target appear for a momentary period and then disappear, repetitively, as long as/ whenever the chassis moves. The firer is expected to shoot at the target only when the target appears. Such concept / system already exists in the field of sports-shooting, i.e., the sports firing ranges have specially designed mechanisms, fitted permanently in the range, which facilitate flash appearance & dis-appearance of target. However, the point to be noted & the biggest constraint in such an arrangement/ system is that, the range cannot be used for any other purpose. Hence, the sports system is considered not suitable for the current requirement because in the present requirement, the firing ranges in field stations should be usable for other modes of firing also, i.e., static firing as well as other modes of moving target firing – as already mentioned earlier. Another hindering factor of the existing concept is that, the cost of the mechanism used in sports firing, is highly expensive, and it thus becomes another reason for non-feasibility to implement at field stations level, due to budgetary constraints of unit's resources. Hence, there arised a necessity to go for a new/ different solution, other than the existing one. Accordingly, for this module, an innovative concept is conceived in which the horizontal motion of chassis is converted into 'flip motion' of the target with the help of specially designed mechanism (SDM), consisting of a cam and spring-loaded shaft. When the chassis moves, the SDM makes the target to flip and hence make it appear & disappear like a flash. Schematic sketch is as shown in Fig 2.11 & 2.12. Module 3 consists of a superstructure with specially designed mechanism (SDM) which can convert horizontal motion of chassis into flip motion of the target with the help of cam mechanism & spring-loaded sliding shaft. Initially, the target, by default will be in 'dis-appear' mode. As the chassis moves horizontally, the specially designed mechanism (SDM) converts this horizontal motion into flip motion of target, thereby causing it to 'appear' for a fraction of time. A firer is required to fire/ shoot at the target whenever it 'appears'. This cycle of appearance & dis-appearance of the target continues, as long as the chassis keeps moving. It is pertinent to note that this design concept to generate flip motion in most cost-economical means was challenging.

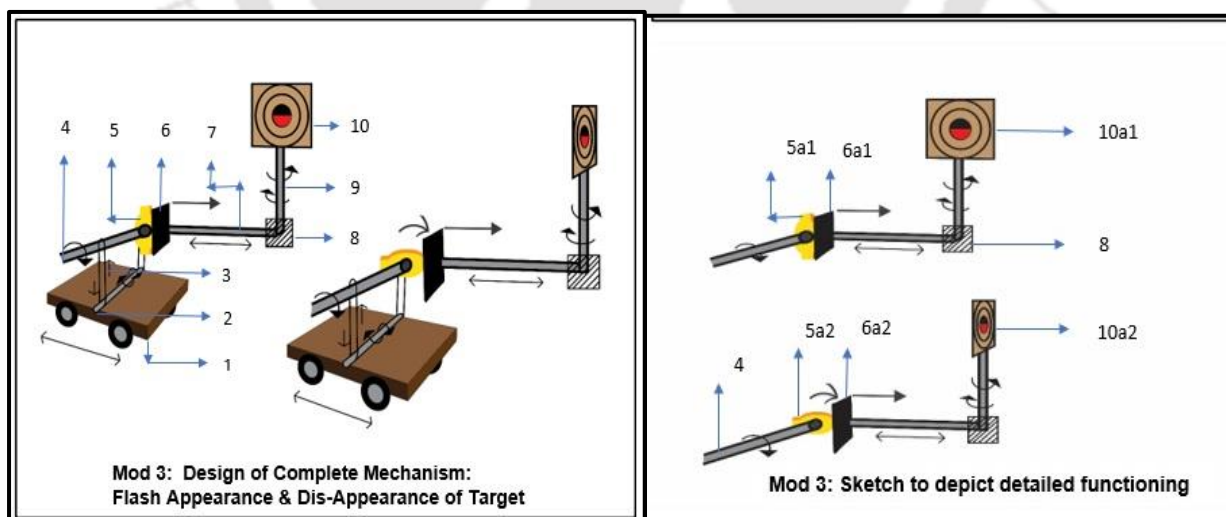


Figure 2.11 : Module 3 Design: Flash Appearance & Dis-appearance of Target

<b>Legend:</b>	
1 -	Moving Platform with 4 Wheels
2 -	Horizontal Shaft driven by wheels of moving platform
3 -	Belt drive to transfer motion from lower shaft (2) to upper shaft (4)
4 -	Rotating upper shaft which houses Cam Mechanism (5)
5 -	Cam Mechanism housed on upper shaft (4)
6 -	Flat plate fixed on one end of sliding shaft (7), towards the Cam end
7 -	Sliding shaft which houses Target Flip Mechanism (8) on one end and a flat plate (6) on the other end
8 -	Specially Designed Target Flip Mechanism which converts sliding motion of shaft (7) into flip / twist motion
9 -	Support Structure to hold the target
10 -	Target which flips as sliding shaft (7) moves back & forth
<b>Note:</b>	
When shaft (4) rotates, it causes cam (5) to push flat plate (6) back & forth along with sliding shaft (7). The Specially designed Target Flip Mechanism (8) converts sliding motion of sliding shaft (7) into flip / twist motion. This gets transferred to target (10) through the support structure (9) which is connected to the flip mechanism.	
5a1 -	Cam in vertical position; Flat plate is closer to rotating shaft (4)
6a1 -	Flat plate in initial position
10a1 -	Target in initial position, <u>i.e.</u> fully visible condition
5a2 -	As shaft (4) rotates, Cam moves to horizontal position thus pushing flat plate (6) away; As shaft continues to rotate, cam comes back to its original (vertical) position. So, flat plate also moves back to its original position.
6a2 -	Flat plate moves back & forth due to cam motion
10a2 -	Target in partially visible condition (minimal visibility) due to getting flipped

**Figure 2.12 :** Design Legend: Mod 3: Flash Appearance & Dis-appearance of Target

### 2.3.6.5 Design for Module 4: Random Motion of Target

In case of module-4 too, it is pertinent to note that, it is practically very difficult to generate random motion of target through a physical model (electro-mechanical means) as compared to generating the same through a simulation software. Hence, for this module too, this challenge was successfully accomplished by conceiving an innovative design, in which, horizontal motion of chassis is converted into random oscillatory motion. The target motion is termed random oscillation because, the amplitude of target oscillation is unpredictable and the frequency of oscillation is disturbed. This oscillatory motion of target with unpredictable amplitude and disturbed frequency of oscillation is hence considered akin to 'random motion', suitable to be used as a training aid. To achieve this, a specially designed mechanism (SDM)

consisting of cams & spring-loaded shafts is utilised to induce oscillations into the target while the chassis moves horizontally. The simultaneous motion of chassis and targets together, causes the targets to oscillate with unpredictable amplitude and frequency. Since the direction of target travel changes frequently, along with that of the chassis, this adds to further randomness of the motion. Schematic sketch of this mechanism is as shown in Figs 2.13 and 2.14 below.

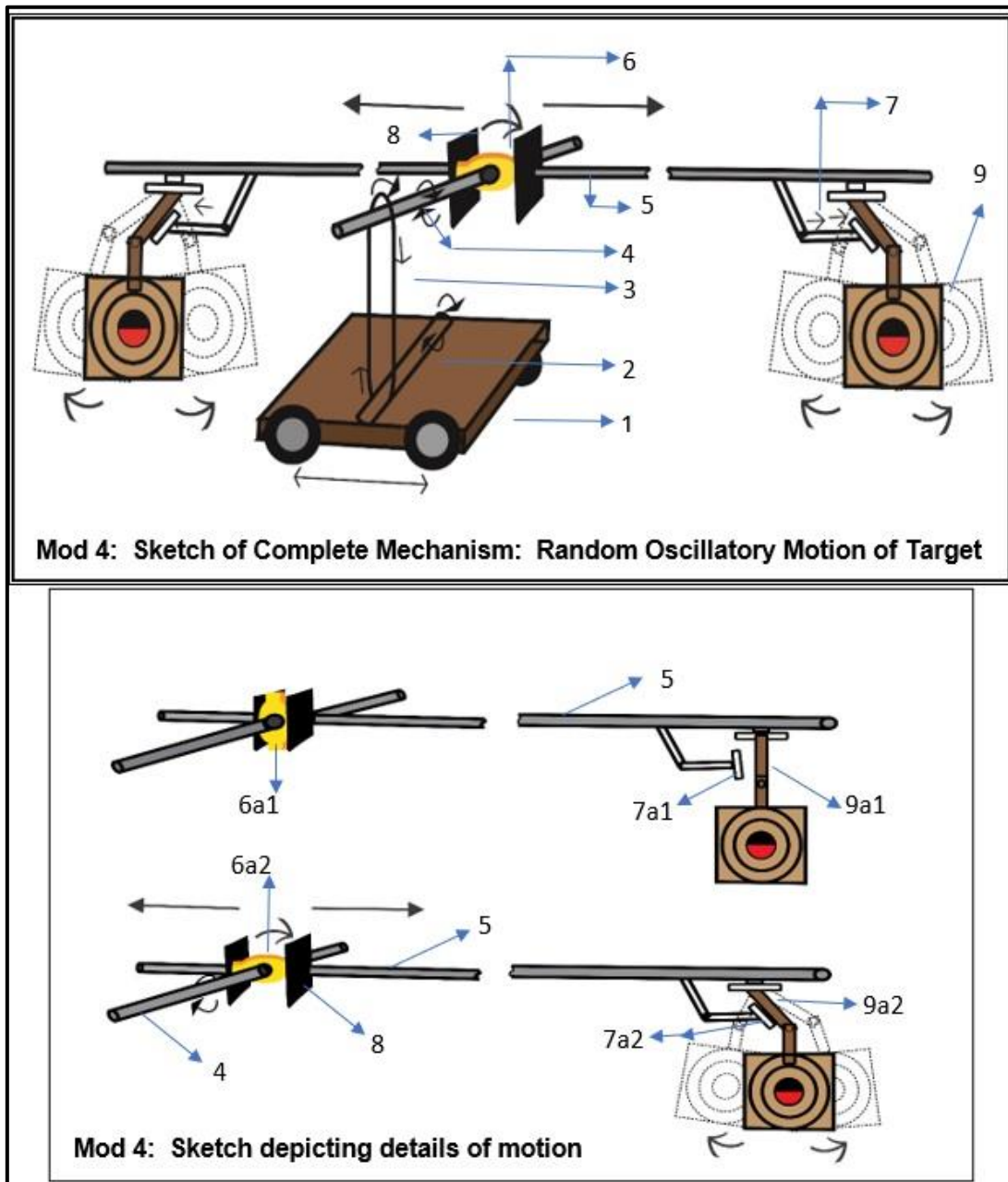
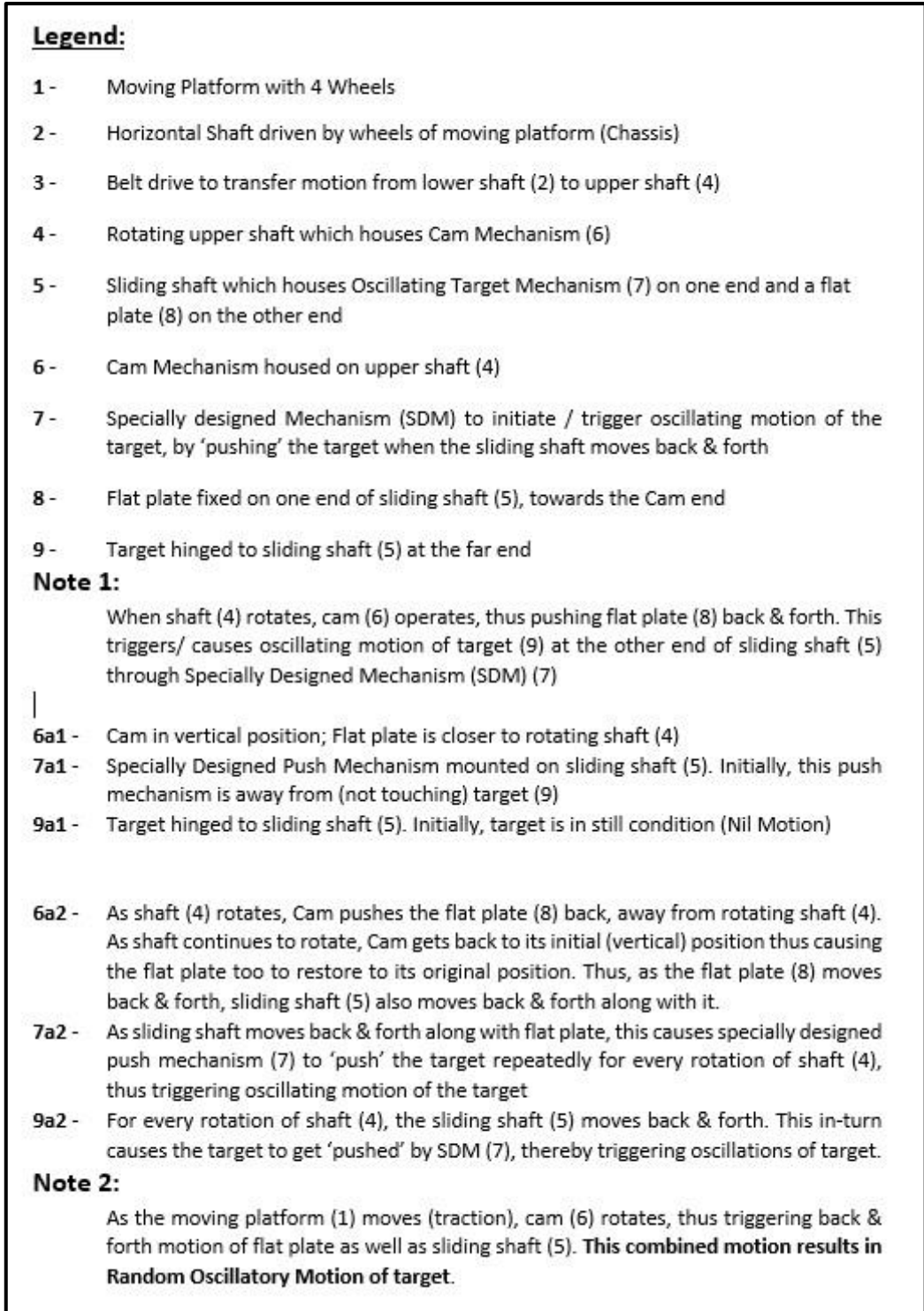


Figure 2.13 : Design for Module 4: Random Oscillatory Motion of Target



**Figure 2.14 :** Design Legend of Mod 4: Random Oscillatory Motion of Target

At this stage, the designs (2D-drawings) for working model to impart training have been finalised, consisting of four different modules, with each module specially designed for generating a particular type of motion as described. Fabrication of working model based on these designs is discussed in following chapter.

## CHAPTER 3: Development of Working Model & SOPs

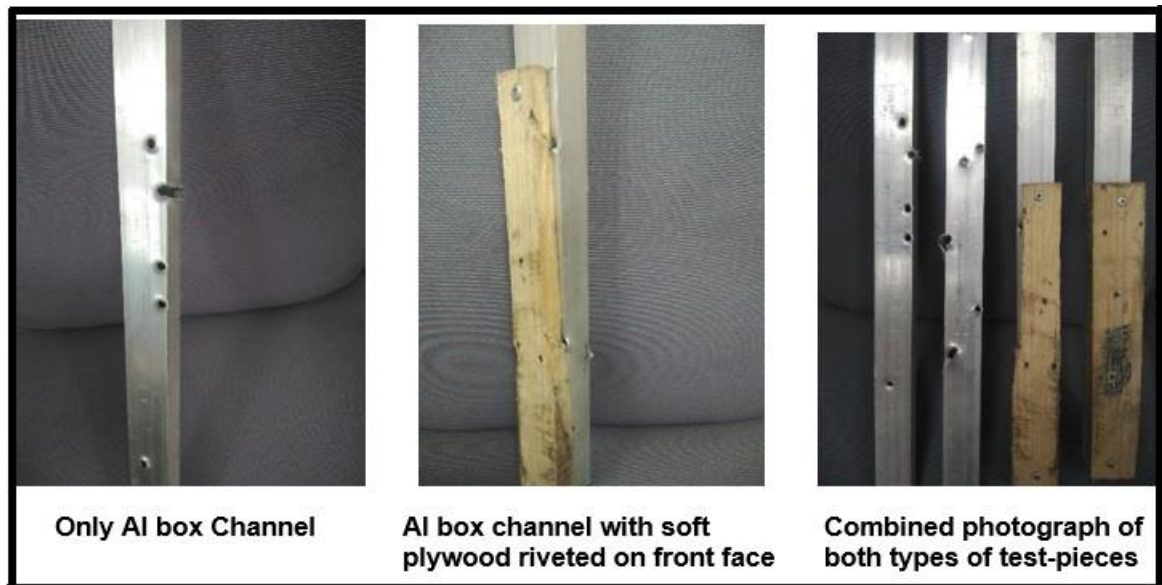
Finalisation of detailed designs (2D-drawings), helped to get a clear insight of various requirements associated with fabrication of working model in terms of dimensions of various sub-accessories, sequence of fabrication, types of material for fabrication, availability/suitability of standard parts commercially available, etc. Apart from fabrication of working model, detailed SOPs (Standard Operating Procedures) have also been formulated for operations, maintenance, and for safe storage/ transportation of the model as well. All these details associated with the fabrication of model as well as with formulation of SOPs are discussed in detail in subsequent paragraphs.

### 3.1 Consideration of Essential Characteristics for Fabrication

At design stage, there are two fundamental guiding factors that have been taken as reference for the process of fabrication of working model. They are, (i) the MTT model should be utilisable in existing open firing ranges and (ii) the MTT model should be such that, during use, no part/ accessory of the model should be visible in the target area, so as to avoid accidental damage by bullet hits. And also, after use, the MTT model should be easily removable from the range so that the range can be used for Static firing. That is, the presence of MTT model should not cause any hindrance for conduct of static firing subsequently. The next most important factor considered is the necessity to ensure that the all materials used for fabrication of prototype are 'Ricochet Proof'. This is considered highly essential because, the proposed prototype is planned to be utilised in a firing range where live bullets are used for practice firing. Hence safety is paramount. By definition, Ricochet is described as the phenomena, wherein, a bullet after hitting a hard surface, (accidentally or for any reason), takes altogether a different path (de-tours), instead of getting embedded in the stop butt. Such bullet is a potential risk/ threat to life as well as to property, in the firing area. Hence, all procedures/ practices applicable in a firing range are required to ensure that they DO NOT lead to ricochet at any cost. With these factors in the backdrop, the following aspects have been taken into consideration which have the potential to add value as well as economy of effort during fabrication process.

- (i) **Ricochet Proof materials for fabrication of prototype:** In general, for any fabrication process, flat bars of mild steel (MS) of different thicknesses are used. They are available commercially in different shapes such as L-channel, I(I) – channel, C-channel, hollow-box channel etc. Similar shapes of aluminium (Al) make also are available commercially. The choice of material depends fundamentally on load bearing requirements and also on the strength-to-weight ratio. It is also governed by cost-factor. MS make is heavier & relatively very strong as compared to Al make materials. Cost wise too, MS is relatively cheaper as compared to Al. However, in the present scenario, where 'Ricochet Proof' being the fundamental requirement, initially, all materials have been tested for this property, by subjecting them to live-firing tests. Through field trials, it has been TESTED & VERIFIED BEYOND DOUBT that hollow box structures of Aluminium (Al) make, have the LEAST POSSIBILITY FOR RICOCHET, as compared to any other shape or of any other make (MS). To be doubly sure, (to add additional safety factor), the test-piece made of Al box structure was riveted with soft wood on the front face and subjected to live firing. During test trials, it has been observed that, there was 'NIL' ricochet in case of both models, i.e., test-piece made of only Al box as well as test-piece made of Al box with soft wood riveted on its front face. Thus, by this process, they are considered to have 'passed' the ricochet-proof test satisfactorily. A few photographs of proof for nil ricochet possibility on Al box

structures, with and without soft ply wood are shown below in Fig 3.1 for ready reference.



**Figure 3.1 : Photographs for Proof of Ricochet Test Trials**

- (ii) **Overall Weight of the System:** From the point of view of strength to weight ratio, box structure of Al make is the best choice to give highest strength to lowest weight ratio, vis-à-vis any other flat sections shape of Al make (L or T or C channels). Another additional advantage of Al box channel over other flat sections is that it has been tested and found to have better characteristics for ‘ricochet proof’ too. As such aluminium is corrosion resistant, and hence this characteristic shall serve as another added advantage. Weighing all these aspects, box structures of Al make are considered as best suited as raw material for fabrication, both in terms of adequate strength as well as minimal weight. As an additional safety precaution, a thoughtful/ considered decision has been taken to rivet the ‘front face’ of the fabricated assemblies with soft wood, for additional protection against ricochet. ‘Front face’ refers to the side which faces the firer, i.e., as seen (visible) from the firer’s point, and is exposed to bullet hit.
- (iii) **Travel Speed of Chassis:** The chassis is required to move to & fro, along the width of the firing range, i.e. the firing area. The average width of firing area of standard 25 yards range is approximately 60ft. Hence, the travel speed of chassis has been taken as 4ft/sec (= 4.36km/hr), so that it shall cover one side distance of 60ft in 15 sec approximately. This is taken as basic reference value, based on which all other related calculations are made. Speed variation mechanism/ system is also included as part of design to vary the travel speed of chassis upto 10ft/sec (= 10.91kmph = 10sec of travel from one end to the other). However, for the purpose of this study (firing practice), travel speed of chassis is maintained constant at 4ft/sec (= 15 sec travel from one end to other).
- (iv) **Dimensions of various sub-assemblies, superstructures, etc:** The dimensions chosen/ finalised for fabrication of various mechanisms, the criteria used to choose/ finalise dimensions for various sub-assemblies, the detailed elaboration of fabrication process of various modules, are all explained in detail in subsequent write-up. Prior to that, in a broad sense, the fundamental guiding principle in finalising the dimensions is

that, the dimensions of fabricated spares are so chosen so that, they ‘match-up’ with the dimensions of the commercial spares, with which they are planned to be used in combination with. For example, when fabricating a drive shaft to transfer drive from electric motor to chassis, the dimension of shaft’s diameter is so chosen such that it matches with the dimensions of the commercially available drive-transfer pulley. Another guiding principle is that in case one sub-assembly is already fabricated earlier, by virtue of it being prior in sequence of fabrication, then in such cases, the dimensions of sub-assemblies to be manufactured subsequently are so chosen, so as to match with that of the one already fabricated earlier. For example, since the chassis is manufactured first in sequence, as compared to any other superstructures of various modules, the dimensions of superstructures (breadth & width) are so chosen, such that they match with that of the already fabricated chassis. Though this method, outrightly, may sound very primitive, it needs to be appreciated that in an environment of experimentation, and/ or progressive fabrication of a model as this is, and in the absence of any prior reference of such work (fabrication) in the past, (this being a pioneering work), this is considered the most practical approach, for the given situation/ conditions.

- (v) **Spares & Raw materials required for Fabrication:** The list of spares and raw materials required for fabrication of various sub-assemblies and mechanisms is explained in detail, along with the reasons for such selection. Sub-assembly wise, details are as explained below:
- (a) **Track:** ‘C’ channels of Al make is finalised to fabricate the track. ‘C’ shape has a twin advantage. First, it has the advantage of good strength to weight ratio. Second, it’s hollow structure (open on one side) permits to accommodate the wheels of the chassis inside the hollow, thus leaving NIL chance for the wheels to slip while rolling. For example, if the wheels run on an ‘T’ channel (like railway wagon wheels), there is a probability/ chance that wheels may slip. But such chance is Zero in case of ‘C’ channel. Further, the support members to strengthen track are fabricated with ‘L’ channels of Al make. ‘L’ channels are selected since they can provide adequate support strength at lesser weight (& in turn cost lesser).
  - (b) **Chassis:** Al make box structures are chosen to fabricate the rectangular platform of the chassis. Al make Box structures have good load bearing strength to hold various superstructures along with targets, yet remain light in weight. Since small wheels of requisite size, to fit into the ‘C’ channel of the track are not available commercially, fabrication of wheels, of desired size & strength, is resorted to. After a thorough study, industrial grade Teflon Round Bars have been identified as the most suitable material to manufacture wheels for chassis. Industrial grade Teflon bars have excellent load bearing strength, good wear resistance and yet light in weight.
  - (c) **Motion Drive mechanisms:** All motion drives are achieved with the help of commercially available V-belts of rubber make and pulleys of wrought iron castings. However, in cases of Mod 3 & 4, big size pulleys (6” Ø) were required to suit the requirement. Since wrought iron pulleys of that size were noticed to be too heavy, which was resulting in additional load (weight) on the system, pulleys were fabricated using industrial grade Teflon bar, since it meets the strength-to-weight characteristic.

- (d) **Superstructures for modules:** The load bearing members of all four modules are fabricated with box channels of Al make for obvious reasons of good strength to weight ratio, as explained earlier.
  - (e) **Specially Designed Mechanisms (SDMs):** SDMs were necessitated in case of modules 2,3&4, to generate specific type of target motion, for which they are designed. Thus, for all these three modules (Mod 2,3&4), SDMs were required to be fabricated over and above the individual superstructures. All SDMs are innovatively conceived and custom-designed to suit specific purpose. Very basic generic spares such as spring-loaded shafts, cams, pivot or hinge joints, etc are used to fabricate all these SDMs. The only exception is Mod 1, which did not require a SDM. During the fabrication of SDMs, different types of joints – pivot, ball, hinge joints, were used as per requirement. For example, a pivot joint is used when rotary or oscillatory movement is necessitated in the same plane (as that of the joint). Whereas, a hinge joint is used to facilitate to & fro movement, like in a door. Module wise details of SDMs are explained in detail, subsequently.
  - (f) **Shock-Absorber System:** Shock absorber springs were not conceived in the initial stages of design solution. However, during practical experience of initial trials, it was realised that there is a need to bring the moving chassis to a quick, yet smooth halt. Quick because, the additional length of track beyond the firing area is only 5-6 ft. Hence, instant halting was necessary, which necessitated a highly effective braking system. However, inclusion of a conventional brake system in the design meant additional components, additional weight and associated complexities. Hence to avoid all this, ‘shock absorber system’ was included in the design as an alternate solution. It was conceived to serve as a brake by absorbing the kinetic energy of the chassis motion, thus bringing it to a smooth halt. Another factor favouring shock absorber system (over a brake system) is the low travel speed of chassis (@4 ft/sec), which could be easily brought to halt with the help of shock absorber system.
  - (g) **Electrical Accessories:** All electrical spares and accessories such as electric motor (to power the chassis motion), On-Off switches, wires, circuit breakers, etc all are of ‘ISI standards’, available from commercial sources. All items work on standard 220v, 50Hz commercial power supply (Indian power supply specs). This obviates any additional expenditure required to cater to any special power supply.
  - (h) **Mechanical Accessories:** All mechanical spares such as nuts & bolts, quick-release mechanisms, rivets, turnbuckles, pulleys, etc of requisite sizes, are all bought from general hardware stores. It was ensured that all spares & raw materials used for fabrication are sourced from readily available commercial sources so that availability of spares for subsequent maintenance (repairs or replacements) is not held up for want of spares (non-availability of spares).
- (vi) **Principle of ‘Ease of Assembly & Dis-assembly’:** Since this system is conceived modular by concept, there is a necessity for repeated assembly & dis-assembly of the superstructures of various modules to the chassis. That is, if a particular type of target motion is to be generated for firing practice, (say for eg: mod 1 for horizontal motion), then, that particular module’s superstructure is required to be assembled on the chassis. Subsequently, if a different type of target motion is planned for practice (say, mod 2 for Slant motion), then, mod 1 needs to be dis-assembled, to make way (space) for fitment of mod 2 superstructure on the chassis. This pattern continues every time, whenever

change of mod (change of target motion) is desired. Hence, a thoughtful & considered decision has been taken that various mods shall be fitted to chassis through ‘quick-release’ mechanisms, which are simple, quick and yet very effective in terms of bond-strength. The purpose was to ensure ease of effort as well as to save on time, over & above ensuring requisite structural strength through joining/ assembly. Further, from the initial stages itself that, all assembly & dis-assembly operations should be do-able with simple basic tools such as common screw driver, cutting plier, small hammer, etc so that degree of difficulty to assemble or dis-assemble, is minimised to the lowest. The same was ensured during fabrication.

### 3.2 Progressive Sequence of Fabrication

The various sub-assemblies and accessories of the working model have been fabricated in a progressive sequence. That is, items related with the basic frame work, such as track, main structure of the chassis, accessories for drive mechanism, etc, were manufactured first. It was subsequently followed up with fabrication of accessories for individual modules. The details are as described below.

- (i) **Track:** The track is fabricated using ‘C’- channels of Al make. The channels are welded together to form a total length of 70-72 ft. The support members to strengthen the track are fabricated with L-channels of Al make. The track along with support members is initially levelled and subsequently grouted into the ground to ensure adequate sturdiness. Photos of track, during and after fabrication/ grouting are as shown in Fig 3.2 below.



**Figure 3.2 :** Photos depicting Track, during & after Fabrication

- (ii) **Electric Motor & Accessories for Traction:** Commercially available single phase electric motor of one-HP capacity (ISI standards) is installed to generate driving force for traction. Motor power is transferred to the chassis through a flywheel, drive shaft & pulleys of appropriate sizes. V-Belts are used to transfer the drive from electric motor to flywheel. Two such Motors are used, one on either end of track. Schematic arrangement is shown in Fig 3.3 above.



**Figure 3.3 :** Electric Motor & Flywheel

- (iii) **Chassis:** The chassis is fabricated using box channels of Al make. Four pieces are welded together to form a rectangular platform. Four wheels are fabricated from industrial grade Tefflon round bar, which are mounted at the four corners of the chassis through suitable mechanism. A custom designed structure is fabricated using Al box

channel of requisite lengths. It is welded on either side of the chassis to serve as a support structure for quick coupling / release mechanism, useful to mount various modules to the chassis. A picture of chassis along with the structure is as shown in Fig 3.4 below.



**Figure 3.2 :** Chassis with Custom Designed Superstructure

- (iv) **Module 1: Horizontal Motion:** A special frame is fabricated using Al box channel, which can hold three targets at a time. The dimensions of superstructure vertical members (legs) of this frame are matched with that of the vertical support members on chassis so that, when inserted, they become a perfect fit. A quick release locking mechanism is used to keep both frames intact. The photo of special structure (to hold targets) is as shown in Fig 3.5 (LHS) and the photo of the complete assembly of mod 1 is as shown in Fig 3.5 (RHS). It can be noticed from the photo (RHS-part) that, after fabrication, ‘front-face’ of the complete assembly is riveted by soft wood (pale yellow colour) for additional safety against ricochet.



**Figure 3.3 :** Specially Designed Structure (LHS-part ) along with Complete Mod 1 Assembly (RHS-part)

- (v) **Module 2: Slant Motion:** As mentioned earlier, at para 2.3.6.3 (chap-2), in mod 2, slant motion of target is achieved by the combined resultant effect of vertical motion of target along with horizontal motion of chassis. An inverted-U-shaped ( $\Pi$ ) frame is fabricated to house a specially designed drive transfer mechanism, which is used to convert horizontal motion of chassis into vertical motion of target. Drive transfer is achieved with the help of two V-belts, to which two targets are attached, one each on one belt. The  $\Pi$ -shaped frame is fabricated with Al make box channels. During practical experience, it was realised that, though average width of range is 60ft, for the purpose of practice firing for mod 2, the practical/ actually useful travel distance of chassis is only 48-50ft. Another realisation is the difficulty associated with moving a 12 ft high structure as initially conceived. Accordingly, the vertical travel of target was re-worked to be around 4 ft (instead of originally planned 10 ft). That is, as chassis moves 48-50ft horizontally, the target needs to move 4ft vertically. Thus, a speed reduction ratio of 1:12 was finalised, in place of the initially conceived 1:6. Accordingly, the height of  $\Pi$ -shaped superstructure is deduced to be around 6 ft. Based on field-trials' experience, a 'target-guide mechanism' was also fabricated and fixed to the  $\Pi$ -structure, to prevent swaying of targets while moving vertically. Photo of the  $\Pi$ -structure along with guide-mechanism, as well as photo of complete mod 2 system after completion of fabrication process, is shown in fig 3.6 below. Here too, it may be noted that, 'front-face' of the complete mod assembly is riveted by soft wood (pale yellow colour) for additional safety against ricochet.



**Figure 3.4 :** Photo of  $\Pi$ -structure with target-guide mechanism (LHS), along with Photo of Complete Mod 2 Assembly (RHS)

- (vi) **Module 3: Flash Appearance:** In Mod 3, the target is required to ‘flip’ while the chassis moves horizontally. This flip motion causes the target to appear & dis-appear like a flash (Refer Fig 2.11 & 2.12, @ para 2.3.4.4). This flip motion is required to occur as long as the chassis moves. To fabricate this concept, initially, a frame is fabricated to accommodate a spring-loaded reciprocating shaft. A hinge mechanism is fixed to the same frame in perpendicular direction, such that, when the spring-loaded shaft reciprocates horizontally, the hinge flips vertically. Targets are attached to this hinge mechanism. A cam is fixed on the shaft of the chassis, to serve as a ‘push-force’ to the spring-loaded shaft. Thus, whenever chassis moves, the cam ‘pushes’ the spring-loaded shaft and the spring pushes the shaft back to its original position. Thus, this causes the shaft to reciprocate whenever chassis moves. Whenever the shaft reciprocates, the hinge mechanism causes the target to flip mounted on it, thereby making the target to appear & dis-appear like a flash. Two such systems are fabricated in the design in order to facilitate simultaneous practice for two firers at a time, one on each target. Photo of the specially designed target flip mechanism along with photo of complete mod 3 system is shown in fig 3.7 below. In the RHS part of the photo below, flipping of target can be clearly noticed.



**Figure 3.5 : Specially Designed Target Flip Mechanism of Mod 3**

- (vii) **Module 4: Random Oscillatory Motion:** (Refer Fig 2.13 & 2.14 @ para 2.3.6.5).

In mod 4, a specially designed mechanism (SDM) converts the horizontal motion of chassis into oscillations of the target with random frequency & amplitude. The net result is the random motion (random oscillatory motion) of the target. SDM consists of a spring-loaded reciprocating shaft, which gets ‘pushed’ by a cam. Targets are hinged at the end of this sliding (reciprocating) shaft. Thus, whenever the chassis moves, the cam pushes and causes the shaft to reciprocate. This in turn, induces oscillations into the target hinged at the end of shaft. By default, the frequency of target oscillation and that of ‘cam-push’, always remains non-matching. This results in unpredictable amplitude & frequency of target oscillations, thereby resulting in random oscillatory motion. Frequent change of travel direction of chassis, every time it reaches one of the ends of the firing range, adds to the randomness of target’s motion.

Initially, Qty two, T-shaped frames are fabricated with Al box channel. They are interconnected with a rotating shaft and with the help of suitable bearings. Two reciprocating shafts are fabricated using hollow pipes. Hollow, for weight reduction.

These hollow shafts, after being spring loaded, are attached to the T-frames, one each. Targets are hinged to these spring-loaded reciprocating shafts, at their outer ends. Thus, when chassis moves, SDM induces random oscillatory motion to targets. Four such systems are fabricated in the conceived design, to ensure equitable load distribution on chassis, and in turn, it's smooth travel, i.e., without any tilt, attributable to uneven load-distribution. The added advantage is that, four firers can practice firing simultaneously, one for each target. Photo of the specially designed mechanism (SDM) along with photo of complete mod 4 system is shown in fig 3.8 below.



**Figure 3.6 : SDM of Mod 4 along with Complete Mod 4 Assembly**

### **3.3 SOPs – Standard Operating Procedures**

In the proposed concept of moving Target System, it is conceived that it shall be used to impart firing training/ practice on moving targets, as an additional training, over and above the existing curriculum. The purpose is to enhance the accuracy of firing skills, especially on moving

targets. The proposed system/ concept being completely new, it was considered necessary that clear and detailed instructions are necessary for operations as well as for safe maintenance of this system. Hence Standard Operating Procedures (SOPs) have been formulated for assembly & dis-assembly of individual modules, for maintenance, and for safe Storage & Transportation. All these SOPs have been annexed as Appendices to this report, the details of which are as given below:

- (i) Appendix 2: SOP for Maintenance
- (ii) Appendix 3: SOP for Safe Storage & Transportation
- (iii) Appendix 4: SOP for Assembly & Dis-assembly of all Modules

### **3.4 Summary**

The progress of research work till now is summarised here. Initially, various possible methods to impart moving target training (MTT) by conventional means, i.e., using open firing ranges, have been explored/ conceived. Various factors that have significant influence/ impact on MTT by physical means have also been listed and described thoroughly. Based on these factors as criteria, various conceived ideas have been cross-evaluated, and finally, 'traction-method' of MTT has been identified as the most suitable method. Accordingly, designs (2D-drawings) have been finalised for the proposed MTT model. Based on these drawings, a working model has been fabricated in a progressive sequence. The working model consists of a chassis and four independent modules, each capable to generate one specific type of motion. Detailed SOPs have also been formulated for ease of assimilation and implementation. The firing skill assessment methodology as well as the proposed training schedule to impart MTT shall be discussed in next chapter (Chap-4).

## CHAPTER 4 : Proposed Assessment & Training Methodology for Newly Developed Design

Firing proficiency on static targets can be described as the degree of accuracy (firing skill) to fire at static targets. This is assessed/ graded based on an existing assessment methodology. This existing assessment methodology has been thoroughly studied to comprehensively understand the fundamentals of scoring and grading criteria. Various conditions relevant and specific to moving target firing environment have also been taken into consideration. Based on these two guiding principles, a renewed / improvised assessment methodology has been formulated. The whole process is explained in detail below.

### 4.1 Fundamentals of Scoring Criteria in Static Target Firing

The fundamental parameters on which firing skills are graded are ‘Accuracy’ & ‘Grouping’. A standard target used in weapon firing practice on static targets is generally, a square shaped thick cardboard paper (2mm thick), of size 1’x1’(ft). Targets are also available in the shape of human bust too. All targets consist of four concentric circles. The inner most circle with a 3 inch diameter (3" Ø) is called ‘Bull’. The next bigger concentric circle with 6" diameter is called ‘Inner’. The next bigger concentric circles with diameters 9" & 12" are called as ‘Magpie’ and ‘Outer’ respectively. Schematic sketch of a standard target is as shown in Fig 4.1.

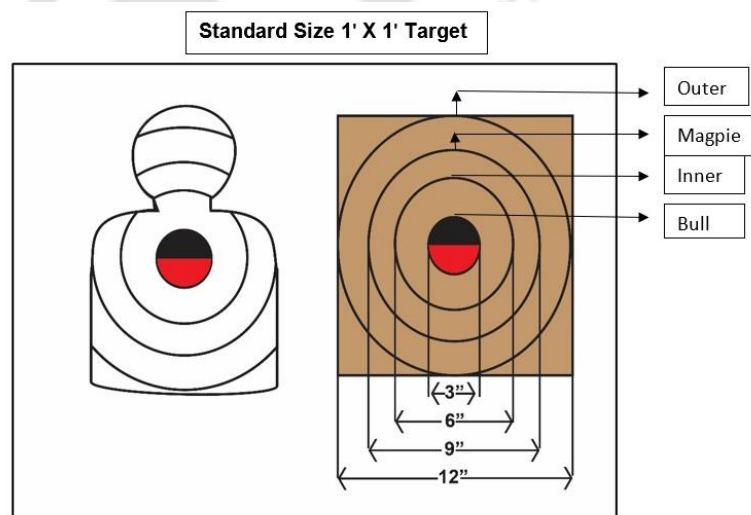


Figure 4.1 : Standard Target

#### 4.1.1 Scoring Criteria: Accuracy & Grouping

As mentioned earlier, ‘Accuracy’ and ‘Grouping’ are two fundamental parameters based on which firing skills are graded (Sabharwal et al, 2012; IAP 3901). Accuracy is defined as the ability to fire at a designated point. It means, and is indicative of the ability of a firer, to shoot exactly at a specified point. On the other hand, Grouping is defined as the ability to keep all shots fired in one spell, as close as possible to each other. Grouping is synonymous to ‘repeatability’ and is indicative of the ability of firer to fire all shots, as nearer to each other as possible. In the existing skill grade assessment methodology in vogue, a firer’s skill on static targets is graded, based on combined proficiency, of these two parameters. For the purpose of skill grade assessment, a group of 5 shots (bullets fired) is considered as a standard spell. As per existing standards, if a shot is fired in the inner most circle of 3" Ø (Bull), then a score of 4 is assigned. For each shot fired in Inner (6" Ø), Magpie (9" Ø) or Outer circles (12" Ø), a score of 3, 2 or 1 is assigned respectively. There shall be NIL score if the bullet misses the target completely. Thus, if a firer can shoot all his 5 shots of a given spell in the bull (innermost circle), then he can score a maximum of 20 (5 shots x score of 4 per shot). The score reduces

as the shots miss the bull and land in outer circles. The exact details of scoring criteria for Accuracy is as tabulated below:

**Table 4.1 :** Table depicting Scoring Criteria w.r.t. Accuracy

Name of Circle	Diameter in Inch	Diameter in Cm	Score per shot	Max Score Possible
Bull	3	7.5	4	5 x 4 = 20
Inner	6	15	3	5 x 3 = 15
Magpie	9	22.5	2	5 x 2 = 10
Outer	12	30	1	5 x 1 = 05
Missed the target completely	>12	>30	0	5 x 0 = 00

**Note:** It is presumed that all 5 shots of a spell are shot in the same circle

Grouping score can be considered akin to ‘bonus score’ awarded for the ability to fire all shots at the same spot or as close as possible. In a spell of 5 shots, grouping is defined as the distance between any two of the farthest shots. Grouping score can hence be considered indicative of the firer’s ability to achieve ‘repeatability’. As per standard criteria in vogue, if the grouping distance is more than 3 inches (3”), it is considered as ‘wash-out’ and hence Nil bonus score is awarded. A bonus of 10 points is awarded if a grouping of 2” is achieved. Thereafter, additional 10 points are awarded for reduction of grouping distance by every 0.5”. That is, a bonus of 20 & 30 points are awarded for a grouping of 1.5” & 1” respectively. Thus, 30 is the maximum awardable score for grouping. The details of scoring criteria for Grouping is as tabulated below:

**Table 4.2 :** Table depicting Scoring Criteria w.r.t. Grouping

Grouping Distance Achieved	3” & above	2”	1.5”	1” & less
Bonus Score Awarded	Nil	10	20	30

**Note:** A maximum of 30 can be scored / awarded for grouping skill

A firer’s skill grade is thus a combination of firer’s ability to achieve accuracy as well as grouping. It is to be noted that, during weapon firing training, these two skills are imparted simultaneously.

#### 4.1.2 Scoring Pattern: Accuracy

From the available statistical data it is evident that, when a firer starts his firing practice to shoot at targets, initially, a few or many of the shots may completely ‘miss’ the target, or at best, hit the outer circles of the target (Magpie & Outer). Over a period of regular firing practice imparted through a well-structured training program, the firers are observed to gradually improve upon their firing skills, both in terms of accuracy as well as grouping. There are many factors which influence the degree of firing skill acquired by a firer. Few such factors which have a significant impact on rate of learning are one’s natural flair or ability to aim/ shoot, physical fitness (good eye sight), Mental fitness (ability to focus & concentrate), motivation level, etc. Hence, inspite of uniform training conditions, different firers are observed to learn

or grasp firing skills at different ‘learning rates’. The degree of skill acquired by firers is assessed periodically, by a standard assessment criteria. From the point of view of ‘Accuracy’, various possible scores, from a stage where all shots ‘miss’ the target completely, to a stage where all shots are shot on/in the ‘bull’, are depicted as shown in table 4.3 below. The data highlights the aspect of gradual improvement in ‘accuracy’. The skill of ‘Grouping’ has not been purposefully deliberated here, and shall be considered later /subsequently.

**Table 4.3 : Shooting Skill Scoring Pattern: ‘Accuracy’ Aspect of Firing**

No. of shots fired in				Total Score	Remarks
Bull	Inner	Magpie	Outer		
--	--	--	--	0+0+0+0 = 00	All 5 shots out of Tgt
--	--	--	1	0+0+0+1 = 01	4 shots out of Tgt
--	--	1	--	0+0+2+0 = 02	4 shots out of Tgt
--	--	--	2	0+0+0+2 = 02	3 shots out of Tgt
--	--	1	1	0+0+2+1 = 03	3 shots out of Tgt
--	1	--	1	0+3+0+1 = 04	3 shots out of Tgt
--	--	1	2	0+0+2+2 = 04	2 shots out of Tgt
--	--	2	1	0+0+4+1 = 05	2 shots out of Tgt
--	1	1	1	0+3+2+1 = 06	2 shots out of Tgt
--	--	--	4	0+0+0+4 = 04	1 shot out of Tgt
--	--	1	3	0+0+2+3 = 05	1 shot out of Tgt
--	--	2	2	0+0+4+2 = 06	1 shot out of Tgt
--	1	1	2	0+3+2+2 = 07	1 shot out of Tgt
--	1	2	1	0+3+4+1 = 08	1 shot out of Tgt
--	--	1	4	0+0+2+4 = 06	Nil shots out of Tgt
--	--	2	3	0+0+4+3 = 07	-----    -----
---	1	1	3	0+3+2+3 = 08	-----    -----
--	1	3	1	0+3+6+1 = 10	-----    -----
--	3	1	1	0+9+2+1 = 12	-----    -----
2	1	1	1	8+3+2+1 = 14	-----    -----
3	1	--	1	12+3+0+1 = 16	-----    -----
4	--	1	--	16+0+2+0 = 18	-----    -----
4	1	--	--	16+3+0+0 = 19	-----    -----
5	--	--	--	20+0+0+0 = 20	-----    -----

#### 4.1.3 Scoring Pattern: Grouping

Grouping score, as explained earlier, is the bonus score awarded to a firer based on the ability to keep all shots fired, as close as possible to each other. By another definition, Grouping is the maximum distance between any of two shots fired in a single spell (5 shots). It is known fact that, the diameter of innermost circle of the target (Bull) is 3". Thus, technically, if a firer has developed the skill to fire all 5 shots of a spell into the bull accurately, then, it automatically

means two things. First, that, he has scored the maximum possible score ( $5 \times 4 = 20$ ) awardable for Accuracy aspect (as can be seen from table 4.3 above). Second, that, in this process of achieving accuracy, he has automatically and parallelly achieved a grouping skill of 3", because, to fire all 5 shots of a spell into bull (3" Ø) it is understood that all shots are fired within 3" Ø. In other words, the maximum distance between any two shots is not more than 3". Thus, it can be stated that a grouping skill of 3" is automatically achieved in the process of achieving the accuracy level to shoot all 5 shots of a spell into the bull. This is a very significant achievement in reality. However, as per existing criteria for skill gradation for grouping, bonus score is awarded ONLY if grouping is 2" and below. Thus, with the presumption that all 5 shots of a spell are fired accurately into the bull, the following table depicts further possible improvements in firing score, based on gradual improvement in grouping skill.

**Table 4.4 : Shooting Skill Scoring Pattern : Accuracy & Grouping Combined**

No	No. of hits in		Score Achieved			Grouping (x) achieved in inches	Bonus Score for Grouping (b) (Max= 30)	Total Score (a+b) (Max = 50)	%
	Bull	Inner	Bull	Inner	Total (a) (Max= 20)				
1	5	--	20	--	20	$x = 3$	--	20	40%
2	5	--	20	--	20	$2 < x < 3$	5	25	50%
3	5	--	20	--	20	$x = 2$	10	30	60%
4	5	--	20	--	20	$1.5 < x < 2$	15	35	70%
5	5	--	20	--	20	$x = 1.5$	10+10	40	80%
6	5	--	20	--	20	$1 < x < 1.5$	25	45	90%
7	5	--	20	--	20	$x \leq 1$	10+10+10	50	100%
Scores Below Depict the Scoring pattern when firer is not able to shoot all 5 shots into the Bull									
8	4	1	16	03	19	$x > 3$	--	19	38%
9	3	2	12	06	18	$x > 3$	--	18	36%
10	2	3	08	09	17	$x > 3$	--	17	34%
11	1	4	04	12	16	$x > 3$	--	16	32%
12	--	5	00	15	15	$x > 3$	--	15	30%
13	--	4 + 1*	00	12	14**	$x > 3$	--	14	28%
	1* shot @ Magpie				** = 12+2			.....and so on....	

## 4.2 Understanding of Existing Criteria for Skill Gradation – Static Targets

The existing skill gradation criteria, has been studied in detail to thoroughly understand & analyse the fundamental concept behind the existing criteria for skill gradation on static targets. Based on this study & analysis, the following aspects are highlighted:

- (i) The ability to shoot all 5 shots of a spell into the 'bull' is considered a significant achievement (milestone), from the skill grade point of view. This is especially so because, it also represents achievement of a grouping skill of 3", achieved simultaneously.

- (ii) Even though when all shots are fired accurately into the bull, it doesn't qualify for being awarded any bonus score as per grouping criteria because, at this stage, the grouping is 3".
- (iii) As per existing criteria for skill gradation, even though a firer achieves a significant skill level (milestone) of being able to shoot all 5 shots of a spell into the bull, score wise, it is only 40% (refer Row 1, Table 4.4). Hence it may be noted/ appreciated that, even though the score of 40% appears to be visibly low, in the parlance of weapon firing skills, it is indicative of a very high degree of firing skill – a skill capable to fire all 5 shots of a spell into the bull .
- (iv) As is mentioned earlier too, grouping skill is awarded in terms of bonus points. In a total score of 50, the proportion of these bonus points is 60% (i.e., 30 out of 50). This is indicative of the importance/ significance of 'grouping' skill. It may be noted that the rate of increase in scores above 40, is very high even with incremental improvement in grouping. For example, when grouping improves from 3" to 2", the overall score increases from 40 to 60, i.e., improves by 20%. But, when grouping improves by additional 0.5" (i.e., from 2" to 1.5") then, the overall score jumps to 80%, an improvement by 40% -. The complete details of incremental improvement are as tabulated in table 4.5 below:

**Table 4.5 : Significant improvement in overall scores based on 'incremental improvement in Grouping'**

Grouping Distance	3"	2"	1.5"	1"
Improvement Margin of grouping from previous	--	1"	0.5"	0.5'(additional)
Grouping Score	--	10	20	30
Total Score	20	30 (20 + 10)	40 (20 + 20)	50 (20 + 30)
Score in Percentage	40%	60%	80%	100%
Proportion of Improvement	--	20%	40%	60%

- (v) The above data is indicative of a significant aspect that, in the parlance of weapon firing skill gradation, though it is a great milestone-achievement to be able to fire all shots in the bull, it is indeed even greater accomplishment to achieve lesser & lesser grouping. In other words, improved grouping skills is considered superior, than that to fire all shots in the bull. Technically, a firer with a grouping skill of 1" & less is called a "Marksman", which is recognised as the highest skill grade.
- (vi) Depending on the demonstrated performance of the firers assessed at periodic intervals, different scores are obtained by different individuals subject to their individual ability to learn, grasp & display the firing skills. As per the existing skill gradation criteria, based on the scores obtained, firing skills are broadly graded into three categories. Details of skill gradation criteria is as depicted in table 4.6 below:

**Table 4.6 : Shooting Skills Gradation Criteria – Existing System**

Score	Below 40	40 to 70	70 & above
Grade	Below Average (BA)	Above Average (AA)	Good (G)

From this gradation criteria, it is evident and can also be construed that a score of 40 is considered as ‘Average’, which represents a very high degree of skill or ability required to shoot all 5 shots of a spell into the bull.

### 4.3 Factors Considered for Proposed Skill Gradation on MTT

There is an established and standard criterion, already in existence for skill grade assessment, used in assessment of static firing skills. However, a necessity was felt to refine these existing criteria, to formulate an improvised criterion, for skill grade assessment of firing skills on moving target training. The factors that influenced this necessity are as discussed below:

- (i) **Lack of clear-cut demarcation to distinguish finer firing skills distinctly.** In the parlance of weapon training, ability to shoot all 5 shots into the bull, is considered a significant achievement/ skill in itself. However, numerically, it corresponds to a meagre score of only 40%. The remaining 60% of the score is dependent on grouping skills only. It is earlier learnt/ observed that, even an incremental improvement in grouping skills shall lead to significant improvement in overall scores. They (overall scores) are segregated into following three divisions, based on incremental improvement in grouping skills (refer table 4.5).
  - (a) Grouping skill between 3" to 2" - corresponds to scores of 40% to 60%
  - (b) Grouping skill between 2" to 1.5" - corresponds to scores of 60% to 80%
  - (c) Grouping skill between 1.5" to 1" - corresponds to scores of 80% to 100%

Whereas, in the existing criteria for skill gradation as represented by table 4.6, scores of 40-70 is graded as Above Average (AA) and scores of 70-100 is graded as Good (G). Hence, technically speaking, there is ‘grey-area’ or a mix-up, in the sense that, a clear-cut demarcation doesn’t exist with respect to the degree of firing skill and skill gradation awarded. The following examples highlight this aspect.

- (a) A firer with 40% score (belonging to 3" grouping) as well as another different firer with 70% score (belonging to less than 2" grouping), are both, clubbed in the same category of Above Average (AA).
  - (b) Similarly, a firer with 70% (belonging to less than 2" grouping), some other firer with 80% score (belonging to 1.5" grouping) and some another firer with 100% score (belonging to 1" grouping), all three, are clubbed in the same category of Good (G).
- (ii) **Lack of clarity to calculate scores used as reference for Skill Gradation.**

The existing methodology of skill gradation for static firing is divided into three groups - below 40, 40-70, and 70-100 (Table 4.6). In this demarcation, there is lack of clarity or ambiguity in the method of calculation for the score of 70%. It can only be logically interpreted. That is, based on existing demarcation of scores corresponding to grouping

skill achieved, the score of 70 can be interpreted as corresponding to a grouping skill between 2" and 1.5" (approximately 1.75"). However, it is to be noted that, it is only logical interpretation but not clearly mentioned. It is thus observed and hence can be stated that existing gradation criteria lacks absolute clarity, especially with respect calculation of scores such as '70%', used as reference for demarcation.

Also, another point to be noted is that, generally, a normal measuring (physical) scale is used in field ranges, to measure grouping distance. Hence, from a practical point of view, measuring 1.75" on a physical scale is not as accurate as measuring 1.5" or 2". Whereas, this issue shall automatically be resolved if, the skill gradation is based on grouping distance, i.e., different classes of skill grades are defined/ established corresponding to grouping distances of 3", 2", 1.5" and 1" respectively. This aspect was taken into consideration while developing the improvised version of skill grade assessment system on MTT.

- (iii) Another major limitation of existing gradation system is that, it does not distinguish firers exactly based on their grouping skill. That is, in the existing segregations/ classifications, firers with different grouping skills are clubbed in the same category. Hence in case of a necessity to distinguish firers, exclusively based on their grouping skill alone, it may not be feasible. Whereas, this issue gets automatically resolved, if firing skill gradations are based purely on grouping skill demarcations. That is, firers are segregated into different classes, based on their grouping skill. This shall enable to easily distinguish firers based on their fine & super-fine skills of firing.
- (iv) Another important aspect highlighted is the difference in the purpose of training on static or moving targets, and the importance of grouping skill, especially in moving target firing. Static target training is a conventional training methodology to impart weapon firing skills, as a part of preparing soldiers for conventional battle-preparedness. Here, the ability to shoot accurately at a relatively distant static target (enemy) is the prime criteria/ focus. Whereas, moving target training (MTT) is proposed to prepare the soldiers for modern days' threat scenario, in which, they are expected to handle & successfully thwart, sudden cum surprise terror attacks, akin to suicide missions. This means, that they are not only to be instantaneous & deft in weapon handling but also be able to fire accurately at attackers moving in different directions simultaneously, in order to retaliate the attackers. In this context, a very high order of firing skill, to that of a high grouping skill, is essential to handle such situations, as compared to that of conventional preparedness. Thus, in terms of imparting training, skill segregation based on grouping-skill reference is considered to be a more pragmatic approach to identify firers distinctly, based on their grouping skill.
- (v) Another aspect from the training point of view on moving target training is that, grouping-skill-based skill assessment is likely to aid more in imparting better training because, such segregation (based on grouping skill) is likely to serve as self-motivator to various firers/ participants, to improve their performance to the next higher level as much feasible (Schneider, 1985). The following examples highlight this aspect:
  - (a) In the existing criteria, since AA covers a span of 40% -70% scores, a firer at 50% (and who is not fine enough to reach 80%) is not motivated to improve his skill any further. But, if skill gradation is based distinctly on grouping, the same firer is most likely to have higher motivation to upgrade himself from 3" group to 2" group – to improve to a score of 60%.

- (b) As per existing criteria, in case of a firer with around 65% score, and who does not have the potential to improvise to 100% is likely to remain not motivated to improve his skill any further. Whereas, if skill gradation is based distinctly on grouping, the same firer is considered to have higher chances to be motivated to upgrade himself from 2" group to 1.5" group (score improvement from 65% upto 80%) or even higher to 1" group (score improvement upto 100%).

#### 4.4 Proposed Skill Gradation Criteria for Moving Target Training (MTT)

Based on above considerations, the proposed Skill Gradation Criteria for assessment of firing skills on moving targets is fundamentally based on segregation of firing skills, based on grouping skills demarcation. The details of proposed system in comparison with existing system is as tabulated below:

**Table 4.7 : Shooting Skills Gradation Criteria – Proposed System**

<b>Overall Score</b>	40% & Below	40% - 60%	60% - 80%	80% - 100%	100%
<b>Grouping Skill (G)</b>	G > 3"	3" ≤ G > 2"	2" ≤ G > 1.5"	1.5" ≤ G > 1"	G ≤ 1"
<b>Proposed Skill Grade</b>	Below Average (BA)	Above Average (AA)	Good (G)	Excellent (E)	MarksMan (M)
<b>Existing Skill Grades</b>	Below Average (BA) 40% & Below	Above Average (AA) 40%-70%	N/A	Good (G) 70%-100%	

The advantage of this proposed system is that the demarcation (skill segregation) is based on grouping skill, resulting into five groups vis-à-vis three groups of the existing system. Thus, this aspect of skill recognition based on grouping skill is likely to serve as a self-motivator to firers, who are likely to be more self-motivated, to improvise upon their firing skills to the next higher level, as much as feasible (Schneider, 1985; Ohlsson, 2011). Another advantage is that, firers can be distinctly distinguished based on their grouping skill. The ready availability of such data is likely to be of significant utility, in specific hypothetical situations, where such necessity exists. Lastly, at training stage, if all trainees, trained on moving targets are imparted adequate skill, atleast to gain a minimum standard of 40% & above, it assures that all firers are capable to shoot at moving targets with a minimum grouping skill of 3" or below. In the context of moving target firing on different types of target movements, this can be considered a stupendous achievement in the context of their enhanced firing efficiency and in turn, their enhanced confidence to handle modern days' security threats.

It is pertinent to note that, the proposal to refine the existing criteria, to formulate a new/ improvised criteria for skill gradation for moving target firing, based on grouping skill acquired, is only and purely in the context of factors and advantages that have been highlighted above. However, this shall in NO case/ way mean that the existing system of skill gradation in vogue is not adequate. It is humbly submitted that, the existing system of skill gradation has with stood the tall test of times and has proven absolutely satisfactory. Hence there is no element of doubt about its suitability, even for moving target training. The intention and purpose behind new proposal is that, it facilitates clear demarcation/ segregation of firers based on grouping skills. One subtle, yet strong advantage of this is that, in a hypothetical situation,

where there is a necessity of database to segregate firers as per their precise grouping skills, in order to deploy them appropriately for specific task (i.e., right man for right job), the proposed methodology shall be instantly useful & effective. However, it is once again re-iterated that, except that the firers cannot be distinguished clearly based on their grouping skills, the existing criteria for skill grade assessment is also considered to be equally effective for skill gradation on moving targets.

#### **4.5 Existing Training Methodology: Static Target Training**

In the existing training methodology currently in vogue, for static target firing training, initially, the firers are imparted with theoretical knowledge of various types of weapons, their safe handling, various Standard Operating Procedures (SOPs) to be followed in firing range for conduct of live firing drills, safety precautions, emergency procedures, etc. Once tested and assessed for reasonable proficiency in their theoretical knowledge, the firers are then exposed to mock firing drills (dummy firing) in firing range. Once familiar with all procedures & precautions of firing drill, only then are they permitted to participate in 'live firing'. This kind of precautionary approach is strictly followed, to ensure that there is nil damage to property or nil risk/ danger to life while conducting the training (firing) sessions. Hence, for moving target firing training too, a similar 'precautionary approach' is considered prudent. Towards this, various factors associated with and which influence this approach are discussed in detail, in subsequent paragraphs.

##### **4.5.1 Static Target Training vs. Moving Target Training**

In case of static target training, by virtue of structured training program, all firers develop adequate or desired skill/ ability to shoot at static targets. Also, every firer, by virtue of individual's natural flair and inherent learning ability, develops certain degree of skill/ ability to fire at moving targets too. However, this degree of skill to fire at moving targets, acquired through one's own inherent learning is not only non-uniform/ dis-similar amongst different firers, but also, far less than the skill that can be imparted through structured training program (Ohlsson, 2011; Lane, 2012). Hence, it can be stated that systematic training program for moving target training is definitely considered a far better option as compared to, being left to one's inherent learning abilities only. For imparting Moving Target Training (MTT), various practical factors & aspects, are discussed below which are considered to have a significant influence in the context of MTT.

- (i) The first and most important practical aspect considered is related to the 'eligibility criteria' to serve as a deciding factor, as to, whether or not, a firer is to be permitted to fire on moving targets. Various reasons and aspects which makes this decision crucial, are discussed below in detail.
  - (a) **Damage to Structure of MTT Modules.** In a firing range, in ideal conditions, except for target, no other item should be visible in the firing zone (target area), as viewed from firers' point, so that, firers do not get distracted. However, in the conceived MTT design, the fabricated module to impart moving target training does have some portion of its modules' structure being visible in the firing zone, over and above the targets. That is, some (minor) portions of the modules' structure shall remain visible in the target area along with targets. Hence, in this context, proficiency of firers in static target becomes an important eligibility criterion to decide, whether or not to permit a firer, to practice moving target

firing. This is because, if a firer, who is already identified as ‘weak’ in static firing is permitted to practice firing at moving targets, then, the risk of damage to MTT system (visible in target area), by a wrongly aimed bullet hit, increases many folds, in comparison with the same risk associated, when a firer with reasonable proficiency in static firing attempts the same.

- (b) It is as an established and undisputable fact that moving target firing is more difficult as compared to static target firing. In this context, the significance of previous skill (in static firing) gains even higher relevance, from the point of view of limiting the vulnerability of accidental damage to MTT structures by a wrongly aimed bullet. Thus, if firers with (proven) low or poor firing proficiency in static targets, are permitted to practice firing on moving targets, the probability of accidental damage is likely to increase multi-fold. This aspect has been practically experienced while conducting field trials. When Below Average (BA) firers were practicing their firing on Mod 1, it was observed that the fabricated structure got partly damaged by accident, more than once. Whereas, when other better grade firers were practicing on same Mod 1, such accidental firing/ damage didn't occur.

Based on field experience, the ‘eligibility criteria’ in terms of ‘previous skill grade’ has been thus formulated that, firers with Below Average grade (BA) shall not be permitted to fire at moving targets. In other words, only those firers with a skill grade of Above Average (AA) or Good (G) in static firing, are considered eligible (to have qualified themselves) to practice moving target firing.

- (ii) **Need for Sequential Training in Moving Target Firing.** Another practical aspect considered significant is the need for sequential training in moving target training. The factors in favour of this consideration are as listed below.
  - (a) Moving target firing consists of firing practice on targets moving in four different directions – Horizontal, Slant, Flash appearance & dis-appearance and Random Oscillatory Motion. It is obvious that the degree of difficulty to predict the target movement is different for different motions. From the training point of view, learning rate shall be more effective, if the firers are imparted training first on ‘relatively easy’ targets, and then slowly graduate to ‘more difficult’ targets [61,104, 105] (Ohlsson, 2011; Smith, 2012; Vogelstein et al, 2020). That is, initially, the firers (trainees) should be exposed to firing on ‘simple moving’ targets, whose degree of predictability of target movement is ‘relatively’ easy. Since the firers are already proficient in static target firing, when they are exposed to fire at relatively easy moving target (simple horizontal motion), the challenge posed is only incremental and hence is likely to serve as motivator to conquer. On the other hand, if the same firer is exposed to fire at a target with very high degree of difficulty in terms of predictability of target motion, then, the quantum of this ‘bigger challenge’ posed to the firer is likely to serve as a deterrent or demotivator. Hence, in this context, it is considered practical & prudent that moving target training be imparted sequentially, i.e., from relatively easily predictable target to a target with higher degree of difficulty in predicting its motion.
  - (b) Amongst the four types of target motions that have been included in the syllabus for MTT, horizontally moving target is obviously the ‘most simple’ & easy to predict. Once, the firers are adequately exposed to firing at horizontally moving

target, the next incremental challenge in terms of 'relative ease' in predictability of target motion is 'slant motion', as compared to other two motions. Hence, firing training on slant motion comes next in sequence, after horizontal motion. The degree of difficulty to predict target motion in the remaining two types of motions, i.e., flash appearance & dis-appearance of target, as well as random oscillatory motion are unique as well as distinct in their own way, and hence are considered quite challenging, in comparison to that of horizontal or slant motion of target. Between the two, flash appearance & dis-appearance of target has been observed to be relatively easy to predict as compared to random oscillatory motion. This is based on feedback obtained from participants during field trials. Hence, for the purpose of training, flash appearance & dis-appearance comes third in the sequence, next to horizontal & slant motions. Training on random oscillatory motion comes last in sequence, as per the relatively highest degree of difficulty.

Accordingly, the sequence of training on moving target training is as summarised below:

- (aa) Initially, training is imparted on Mod 1 – Horizontal motion
- (ab) Next in sequence is Mod 2 – Slant Motion
- (ac) Subsequent training is on Mod 3 – Flash appearance & dis-appearance of target
- (ad) Lastly on Mod 4 – Random Oscillatory Motion of target, considered to be relatively most difficult motion to predict amongst the four.

From a firer's perspective, an important aspect that merits attention here is that, when a firer, who is adequately experienced and proficient on static target firing, is exposed for the first time to moving target training, his unfamiliarity to the new environment of moving targets, poses him a challenge, in terms of his ability to predict the target movement and shoot at it. From the perspective of 'degree of difficulty', the quantum of challenge should be motivating but NOT detrimental or discouraging. Hence, the whole sequence of training, has been deduced such that, at every stage, the degree of challenge to the firers, in terms of difficulty in predictability of target motion, is incremental and thus serves as a motivating challenge, but not as deterring or demotivating. The sequence thus deduced is – MTT is to proposed to be initially imparted on Mod-1 (horizontal motion). It is followed by Mod-2 (slant motion) and further by Mod-3 (Flash Appearance & Dis-appearance) and Mod-4 (Random motion), respectively.

(iii) **Need for Eligibility Criteria at Every Stage of MTT.**

It has already been proposed that proficiency in static firing (previous experience) is considered as an important eligibility criterion to decide, whether or not to permit, firing at moving targets. The same logic is applicable to subsequent levels also, at every stage. That is, initially, for being considered eligible for Mod 1 (entry level to moving target firing – horizontal motion), AA or G proficiency in static firing (previous experience) is taken as minimum qualification requirement (QR). Similarly, in case of mod 2 too, (to impart training on slant motion), the firer is once again subjected to another unfamiliar environment in terms of (further) incremental increase in the 'degree of difficulty' in predictability of target motion. Hence, the premise of need for eligibility criteria stands equally valid in this context too, (i.e., from Mod1 to Mod 2). In the

sequence of training proposed for four different types of target movements, two factors remain more or less equal/ similar in all stages. One is the incremental increase in degree of difficulty in predictability of target motion. The other is the challenging environment to which a firer is exposed at every stage, in terms of ‘unfamiliar target movement’. Hence, it can be stated that ‘proficiency of firing in previous stage’ as eligibility criteria, remains equally valid for every stage of graduation to subsequent higher level i.e., from Mod 1 to Mod 2 or Mod 2 to Mod 3 or Mod 3 to Mod 4. That is, a firer is considered eligible, to be permitted to the next level of moving target firing, only when he attains a minimum of Average grading (A) or above (score  $\geq 40\%$ ) in the previous stage.

#### 4.6 Proposed Training & Assessment Methodology for MTT

The proposed training methodology for moving target training consists of imparting firing training on four different types of target motions as per sequence mentioned above at para 4.5.1. At the end of each training stage, all firers are planned to be subject to ‘performance assessment’ to check the extent of their skill assimilation. Based on the performance demonstrated, they are planned to be graded accordingly. The assessment criteria of firing skills on moving targets is as proposed at para 4.4 above. As per proposed training plan, while imparting training on moving targets, the chassis moves in both directions in the firing range, i.e from left to right as well as from right to left. Thus, firers are automatically familiarised/ exposed to fire at targets moving in both directions. Thus, the assessment of firing skills of firers, on moving targets, is indicative of their proficiency in either direction. For the proposed sequence of training, eligibility criteria as well as skill assessment criteria, at every stage on various modules is depicted in a tabular format as table 4.8 below.

**Table 4.8 : Proposed Eligibility and Skill Grade Assessment Criteria : MTT**

Module	Type Motion	of	Minimum Eligibility Criteria Previous	in	Skill grade Assessment Criteria for MTT	Min Skill grade required for Upgradation to next mod
1	Horizontal		Atleast Above Average in Static Firing		Above 80% : Exceptional 60 to 80% : Good 40 to 60% : Average Below 40 % : Below Avg	Average & Above  (40% & Above)
2	Slant		Average & above in Module 1		Above 80% : Exceptional 60 to 80% : Good 40 to 60% : Average Below 40 % : Below Avg	Average & Above  (40% & Above)
Module	Type Motion	of	Minimum Eligibility Criteria Previous	in	Skill grade Assessment Criteria for MTT	Min Skill grade required for Upgradation to next mod
3	Flash Appearance		Average & above in Module 2		Above 80% : Exceptional 60 to 80% : Good	Average & Above

			40 to 60% : Average	(40% & Above)
			Below 40 % : Below Avg	
4	Random Oscillation	Average & above in Module 3	Above 80% : Exceptional	
			60 to 80% : Good	---
			40 to 60% : Average	
			Below 40 % : Below Avg	

#### 4.7 Proposed Sequence of Progressive Training

As a standard convention, training for static firing is imparted in multiples of spells, each spell being a group of 5 shots/ bullets. Each training session generally consists of 4 spells, i.e., each trainee firer is given an opportunity to fire 20 shots in 01 firing session (Sabharwal et al, 2012; IAP 3901). A maximum of two such sessions are planned per trainee per day. The training sessions for moving target training are also proposed on similar lines. For the purpose of conducting field trials, it is proposed that each trainee shall be imparted 4-10 practice firing sessions. Accordingly, the proposed progressive training sequence is as tabulated below.

**Table 4.9** : Sequence of Proposed Training Schedule

Pre-requisites (Eligibility Criteria)	No. of Proposed Practice Sessions	Proposed Skill Gradation Criteria			
		Below Avg	Average	Good	Excellent
<b>Phase 1:</b>	Horizontal Motion				
Minimum Above Average grading in Static Firing	4 to 10 practice sessions 01 Session = 04 spells 01 Spell = 05 shots	Below 40%	Between 40-60%	Between 60-80%	80% & above
<b>Phase 2:</b>	Slant Motion				
Minimum Average grading in Mod 1 Firing	4 to 10 practice sessions 01 Session = 04 spells 01 Spell = 05 shots	Below 40%	Between 40-60%	Between 60-80%	80% & above
<b>Phase 3:</b>	Flash Appearance & Disappearance				
Minimum Average grading in Mod 2 Firing	4 to 10 practice sessions 01 Session = 04 spells 01 Spell = 05 shots	Below 40%	Between 40-60%	Between 60-80%	80% & above
<b>Phase 4:</b>	Random Oscillatory Motion				
Minimum Average grading in Mod 3 Firing	4 to 10 practice sessions 01 Session = 04 spells 01 Spell = 05 shots	Below 40%	Between 40-60%	Between 60-80%	80% & above

Summing up all the above details, the following features are highlighted:

- (a) Existing assessment methodology for skill gradation has two practical limitations. First, the 'measurement' of grouping skill as per laid down criteria is defined in terms of fractions of an inch, and hence impractical/ highly cumbersome to measure on a measuring scale. Second, as per existing criteria, firers are not segregated based on their grouping skills. Hence, in case of a necessity, where selection/ deployment of specific type (skilled) of firers as per their grouping skill is required to be done, it is not feasible.
- (b) The proposed skill gradation criteria resolve both of the above-mentioned issues. However, as mentioned earlier too, existing criteria can also be utilised for skill gradation on moving targets.
- (c) 'Eligibility Criterion' has been introduced to permit/ not permit firers for moving target firing, based on their initial/ previous skill on static firing. This has been mandated to ensure that no accidental damage occurs on moving target mechanism due to incompetent (less competent) firers. It is as such an established fact that, participants who are unable to excel /perform good in relatively less-skilled (basic skills) job can never cope up (perform better) in tasks/ jobs needing advanced skills.
- (d) The sequence of training on moving targets is proposed in such a way that with each progressive module, there is an incremental increase in the degree of difficulty of target motion. This gradual increment in difficulty is considered to serve as motivator for learners/ participants to conquer the challenge.

At this stage, with all necessary preparations in place, the next phase of research work was to conduct field trials in order to ascertain the effectiveness of the proposed system.

## **CHAPTER 5: Evaluation and Validation of Effectiveness of Newly Developed Training Method in imparting Proposed Training**

Having conceived a design and fabricated a working model, the efficacy of this model to impart moving target training and the effectiveness of proposed training methodology is required to be established/ ascertained. This chapter deals with the validation procedure to evaluate the efficacy of the new developed training model. For this, experimental trials have been planned to test various aspects in an elaborate and detailed manner. The purpose of these experimental trials was two-fold. One, to test the effectiveness of proposed training methodology to impart proposed training using the fabricated model. Two, to check the ability or effectiveness of fabricated model to generate four different types of target motions. The experimental trials were conducted in the existing open firing ranges of one of the field stations (India).

### **5.1 Demographics of Participants**

In order to find out the efficacy of the newly developed modules, three sets of experiments were designed. For conducting these experiments volunteers/ participants were identified from Guwahati station. Guwahati station was chosen because of availability of access & permission to conduct the experiment, by virtue of me (research scholar) working in that station. As a part of proposed training methodology, as per the proposed 'eligibility criterion'(refer para 4.5.1(iii)), it was necessary that the volunteers must have prior knowledge and adequate experience of shooting at static targets. As per the conventional system in vogue, based on individual firing scores, firers are broadly segregated into three distinct groups - Good grade firers (G), Above Average grade firers (AA) and Below Average grade firers (BA). Hence, the total population can thus be broadly divided into these three distinct groups. Out of this, a total of 144 volunteers were selected constituting a heterogenous mixture of these three distinct grades of firers on static targets, through '**Stratified Random Technique**' (Proportional Quota Sampling). This sampling technique was used in order to ensure proportional distribution of all grades of firers.

### **5.2 Formation of Groups for Experimental Studies**

All 144 participants were segregated into groups of four (4) personnel each, forming a total of 36 groups ( $36 \times 4 = 144$ ). The reason for dividing them into groups of 4 personnel each is as explained below:

In any conventional firing range, there are 6 firing positions – 1,2,3,4,5 & 6 (refer Fig 2.1 @ Chap 2, para 2.1). Though there is additional area/ firing zone in which more firing positions can be included, such area (zone) is intentionally left out on both sides of the firing range, in order to ensure that adequate safety margin is catered for. This safety margin is required to prevent any kind of damage to side support walls of the stop butt area and also to ensure that no bullet crosses the firing area even by accidental mis-fire (incorrect aiming). Since the proposed experiments are associated with moving target firing, which is more difficult than static target firing, it was considered prudent, to cater for (further) additional factor of safety, because of the fact that the participants have no prior experience/ exposure to moving target firing. Accordingly, only the central four positions of firing, i.e., position Nos 2,3,4 & 5 were planned to be utilised for the conduct of experiment, leaving out the extreme positions, i.e., positions 1 & 6. This was a thoughtful consideration based on the premise that, by avoiding the

extreme firing positions 1 & 6, safety compliance is further enhanced automatically, in turn, minimising the chance of any kind of untoward incident/ damage during practice / trials. Since only, the central four positions (2,3,4&5) have been chosen, the participants have been segregated into groups of 4 each. The details of distribution of participants into various groups as per their firing grade is as shown in table 5.1 below:

**Table 5.1 : Distribution of Shooter Groups**

<b>Total Groups</b>	<b>Number of groups - Gradation based on Static Firing</b>					
	<b>MarksMan (M)</b>	<b>Good Shooters (G)</b>	<b>Above Average Shooters (AA)</b>	<b>Below Average Shooters (BA)</b>		
36 +1*	01*	20	11	05		
<b>Total Participants</b> 144 + 3	03	80 (20 x 4)	44 (11 x 4)	20 (05 x 4)		

**Note:** \* Marksman is a mini-group with only 3 firers

It may be noted that, in addition to 144 participants, a mini-group consisting of three (3) Marksmen firers have also been included for the purpose of experimental trials. Marksman, as mentioned earlier, are those exceptional ace shooters, who score a perfect 100%. The purpose of including marksmen was to compare the performance of firers vis-à-vis marksmen with respect to grasping of firing skills.

Earlier at para 4.5.1 of chap 4, it was stated that, skill grade of previous experience shall be taken as ‘eligibility criteria’, whether or not to permit firers to participate in moving target firing. Accordingly, it was mentioned that Below Average grade firers (scores < 40%) shall not be permitted for moving target firing. However, for the purpose of conduct of these experiments, an exception has been considered to include five (5) groups, i.e., 20 participants of Below Average (BA) grade firers. This has been done for following reasons:

- (i) Firstly, to confirm to the norms of stratified random sampling technique used for sample selection.
- (ii) Secondly, to study the performance of less skilled firers (BA) vis-à-vis better grade firers (G or AA). The purpose was to obtain data through experiments, so as to either support or negate the proposed hypothesis that, ‘less skilled firers (of static) stand lesser chance to perform better in moving target firing as compared to higher/ better skilled firers (of static).

### 5.3 Participants’ Preparation

Before the start of experiments, all the volunteer participants were briefed about the newly fabricated model and the purpose of this experiment. They were made familiar with the details of various modules, various (four) types of target motions, scope of these experiment, inherent limitations, risks associated and all other relevant information regarding conduct of experiments. They have also been clarified that their contribution is purely voluntary and that they may withdraw, if they desire, at any point, without giving any reason. Also, their individual performance data will be confidential and will only be used for academic purposes. After all details have been given, ‘volunteer consent’ has been obtained from all participants.

## 5.4 Evaluation Methodology

The purpose of experiments (field trials) is to evaluate the effectiveness of proposed training methodology to improve firing skills on moving targets and also to ascertain the effectiveness of fabricated model to generate four different types of motions. The detailed scope and criteria for evaluation is as described below.

### 5.4.1 Methodology followed to ascertain effectiveness of proposed training methodology

The effectiveness of proposed training methodology was planned to be ascertained by measuring the improvement in firing skills of firers on moving targets, before and after methodical training. As a thumb rule, the degree of firing skill acquired by a firer is measured/ expressed in terms his firing score. Thus, higher the firing score, higher the degree of skill acquired and vice-versa. Through this experiment, it has been planned to measure the difference (anticipated improvement) in the firing skills of firers, before commencement of training and after completion of training. This comparative study has been planned to be undertaken in the following sequence:

- (i) Firstly, to measure the degree of skill of firers (volunteers), to shoot at moving targets, without any formal training on moving targets. This shall serve as an initial reference point.
- (ii) To provide adequate firing practice to all firers on moving targets, as per proposed methodology, i.e., 6 training sessions, with each session consisting of 04 spells. At the end of 6 sessions of training, the firers are tested for their performance/ skills and their firing scores (degree of skill) are noted.
- (iii) Subsequently, an additional four sessions of training, totalling to 10 sessions (6 + 4 = 10) is planned to be imparted. The degree of firing skill (firing score) is once again to be measured at the end of 10 sessions of training.
- (iv) Finally, to compare the difference in the degree of firing skills, before and after 10 sessions of training, on moving targets. This difference (anticipated increase) in the degree of firing skill shall be indicative of the effectiveness or impact of training to enhance the firing skills on moving targets and thus serve as validation of the proposed training methodology.

In addition to the above, the following additional & related aspects have also been planned to be analysed as per the following sub categories:

- (i) Effect or influence of previous skill grade (in static firing) on the performance of firers to grasp the new skills to shoot at moving targets in different modules.
- (ii) Effect or influence of degree of difficulty of target movement on grasping/ performance of firers
- (iii) Effect or influence of number of training sessions on one's learning skills.
- (iv) All these aspects have been planned to be studied/ analysed with the focus to arrive at the average number of training sessions required for a firer to upgrade his skill level significantly with the help of this firing training. In other words, the aim of these field trials is to study the effect / impact of training on various grades of firers, for different modules (various degrees of difficulty of target movement). Another aim is to study the

number of practise sessions required to score a minimum of 40 & above – which is indicative that all shots are fired in the ‘bull’.

#### 5.4.2 Methodology to ascertain effectiveness of Fabricated Model to Generate Various Target Motions

Another purpose of field trials was to simultaneously check the effectiveness or ability of the fabricated model to generate four different types of motions without any hiccups. Other associated aspects such as ease of operations, ease of maintainability, user-friendliness, etc. have also been planned to be studied to assess the effectiveness of the fabricated model for its intended purpose.

### 5.5 Conduct of Experiments

Experiments were planned to be conducted in three phases as per the scope for evaluation. In the first phase, all participants were made to fire on various moving target modules without any formal training, and their performance recorded. This performance is considered attributable to their inherent / innate skill developed by virtue of their exposure to static target firing. In the second phase, module wise, participants were given firing training for 4 to 6 practice sessions, and their performance was assessed at the end of 4<sup>th</sup> as well as 6<sup>th</sup> sessions. This was done for each module, progressively. That is, initially, all firers were imparted training on Mod1 for 4 sessions followed by assessing their demonstrated performance. It was followed by two more sessions of training (totalling to 6) and performance assessment at the end of 6 sessions. A similar pattern was followed for remaining three modules – 2, 3 & 4, in the same sequence.

In the third and final phase, for those firers who acquired / demonstrated lesser degree of skill in the initial 6 sessions, i.e., who could not score at-least 40%, were provided with additional 4 practice/ training sessions (totalling to 10 practice sessions). Their demonstrated performance was once again recorded, at the end of 10 sessions. The performance data at various stages was recorded and compared to analyse the effect or impact of training (number of sessions) on the extent of learning. The details of each of the training phases and the summary of analysis of performance data at various stages are explained in subsequent paragraphs below. For the purpose of easy reference, the following nomenclature is used:

<b>Actual Term</b>	<b>Nomenclature Used</b>
For various Grades of Firers: }	MarksMan & Exceptional (M); Good (G); Above Average (AA); Below Average (BA)
For Various Modules:	Mod1, Mod2, Mod3, Mod4 for Modules 1,2,3,4 respectively
For Group of four firers (gp): }	First group = gp1; Second group = gp2, and so on

#### 5.5.1 Experiment - Phase 1: Firing Performance without any Formal Training

As mentioned earlier, a total of 144 volunteers were selected for conduct of trials, which constituted a mixture of 80 G-grade firers, 44 AA-grade firers and 20 BA-grade firers, representing 55.55%, 30.55% and 14% (13.89) of the total sample population respectively. In addition, 03 Marksman (M) were also included for these trials. Initially, all the participants were explained about various modules of moving target training system. A demonstration was

given to them, to show all four types of target movements of four different modules. After familiarisation, each of the volunteer participant was asked to fire at the targets in a group of 4, without any formal training on moving targets. Each firer was provided an opportunity to fire two spells of 5 shots each, against each of the modules, i.e., 10 shots each on each module. First, they were asked to fire at Mod 1; then at Mod 2, subsequently at Mod 3 & finally at Mod 4. The results (demonstrated performance) was recorded for each of the firer, in respect of each module, separately. This was to check their initial skill level, before commencement of training on moving targets. The results obtained, module wise, are as tabulated in table 5.2 below:

**Table 5.2 :** Initial skill level of firers without any formal training on moving targets

Initial Grade in Static	Total No. of Participants	Mod No.	Distribution of participants as per their Scores				%age Distribution of Participants as per their Scores			
			Ex Above 80	G 60 to 80	AA 40 to 60	BA Below 40	Ex	G	AA	BA
<b>M</b>	<b>03</b>	M1	3	--	--	--	100	--	--	--
		M2	3	--	--	--	100	--	--	-
		M3	--	--	3	--	--	--	100	--
		M4	--	--	3	--	--	--	100	--
<b>G</b>	<b>80</b>	M1	--	56	24	--	--	70	30	--
		M2	--	12	68	--	--	15	85	--
		M3	--	--	--	Only 64	--	--	--	80
		M4	--	--	--	Only 51	--	--	--	63.75
<b>AA</b>	<b>44</b>	M1	--	03	15	26	--	6.8	34.1	59.1
		M2	--	--	--	44	--	--	--	100
		M3	--	--	--	Only 19	--	--	--	43.2
		M4	--	--	--	--	--	--	--	--
<b>BA</b>	<b>20</b>	M1	--	--	--	20	--	--	--	100
		M2	--	--	--	Only 12	--	--	--	60
		M3	--	--	--	--	--	--	--	--
		M4	--	--	--	--	--	--	--	--

### Performance Analysis: Phase 1 Trials

Firing scores data with respect to performance assessment at initial stage, i.e., without any formal training has been analysed. It has been observed that, the performance of marksman was impressive in Mods 1& 2. Even for Mods 3 & 4, though their scores have significantly dropped, their performance continued to be relatively impressive, in comparison with other grade firers. The following other aspects have also been observed:

- (i) Performance of all firers has been observed to have largely followed a similar pattern as that of their previous grades in static firing. That is, even in moving target firing,

marksman performed better than all other grades of firers; G-grade firers performed better than AA & BA grade firers; AA grade firers performed better than BA grade firers, but were lesser as compared to G-grade firers.

- (ii) Performance of same grade of firers gradually deteriorated for successive modules. That is, for any chosen grade, the performance of firers was better in Mod 1 as compared to that in Mod 2. And, the performance in Mod 2 was better than that to Mod 3 and so on. The performance was observed to deteriorate more & more with Mods 3 & 4.
- (iii) It was also observed that, in quite a few cases, firers (shots) have completely missed the target. The details are as below:
  - (a) In case of G-grade firers, while firing at Mod 3, only 64 (out of 80) firers could atleast hit the target. Rest 16, have completely missed the target. Similarly, in case of Mod 4, only 51 (out of 80) firers could atleast hit the target. Rest of the firers have completely missed their targets.
  - (b) In case of AA-grade firers, while firing at Mod 3, only 19 (out of 44) could atleast hit the target. Rest 25 have completely missed the target. And, in case of Mod 4, none could hit the target.
  - (c) In case of BA-grade firers, while firing at Mod 2, only 12 (out of 20) firers could atleast hit the target. Rest have completely missed the target. And, in case of Mod 3 & 4, none could hit the target.

From the above data, it can be observed that previous skill grade (static) has considerable effect on performance of firers. Further, it can also be observed that, for same grade of firers, their performance has deteriorated with increasing difficulty of target movement.

- (iv) In few sporadic cases, a few shots by some of the BA-grade firers not only missed the target but also accidentally hit the mechanism causing damages to the mechanism. It was required to repair / replace the damaged portion, in order to be able to continue with the trials. This phenomenon was observed with only BA-grade firers. This goes to prove the hypothesis that lower grade firers (BA-grade) are more prone for mis-fire / inaccurate firing and hence can become a potential cause for a likely damage to the moving target mechanism. Thus, the proposed hypothesis “to consider skill gradation in static firing (previous firing) as eligibility criteria (deciding factor) for permitting to fire at moving target training” is considered to be validated.
- (v) From the analysis of above data, the following conclusions have been drawn:
  - (a) Degree of difficulty to predict target increases with each successive module. The same has been confirmed from verbal feedbacks too, received from participants during conduct of field trials.
  - (b) Previous skill grade in static firing does have a considerable impact/ effect on performance in moving target firing. That is, a firer with previously (already) established skill grade in static has been observed to perform, more or less in a similar way in MTT too.
  - (c) Except for Mod 1, all firers of all grades have been observed to perform below average (score < 40%), in all three modules, i.e., mods 2,3,&4. The lesser the grade in previous (static), higher is the deterioration in performance.
  - (d) Verbal feedback from participants indicated that, the effect of planned sequence of modules on the trainees was on expected lines, that is, the sequence served

the planned purpose, to incrementally increase the degree of difficulty to predict target movement, and thus serve as a challenging motivator.

- (e) Based on the performance of BA-grade firers, it can be reasonably concluded that, the proposed ‘eligibility criteria’ for permitting moving target firing (training) stands validated.

## 5.6 Experiment - Phase 2: 4-6 Firing Sessions

In this phase, firing training was imparted to all firers, initially for 04 sessions and subsequently for another 02 sessions, totalling to 06 sessions. Uniformity of training conditions was maintained through-out for all grades of firers and for all sessions. Performance assessment was recorded at the end of 4<sup>th</sup> as well as 6<sup>th</sup> training sessions. In the first phase of experiment, fabricated model got accidentally damaged due to wrongly aimed firing by BA-grade firers. This resulted in delay of conducting/ continuation of trials till the time the damaged portion was repaired. Parallely, it was also observed in the first phase that demonstrated performance of firers was more or less, matching with their previous skill grade (in static). That is, marksman scored better than that of G-grade firers, G-grade firers scored better than AA-grade firers and AA-grade firers scored better than BA-grade firers. With these experiences and observations, and in order to avoid any such delays in conduct of pahse-2 trails, it was decided that pahse-2 trials shall first be conducted in respect of Marksman, followed by G-grade firers and AA-grade firers respectively. BA-grade firers have been planned at the end. It may be noted that this sequence was followed, purely to avoid any possible delay in conduct of trials owing to any accidental damage due to mis-fire and the subsequent ‘down-time’ of the system till it is repaired. The grade wise summary of trails conducted, the results of performance recorded, their analysis, are all described in following paragraphs.

### 5.6.1 Phase-2: Ace Shooters (Marksman -M)

There were 03 ace shooters (Marksman), who were constituted into a separate mini group, who volunteered to participate in this experiment. After initial familiarisation on the experimental set up, it was initially planned to give six practice sessions as per standard plan, common for all grades of firers. However, in case of marksmen, for Mods 1 & 2, within 2-3 practice sessions itself, the three marksmen scored more than 90. Their performance / results were so encouraging that, 2-3 sessions itself were found adequate. In case of Mods 3 & 4, by the end of 4 practise sessions, significant progress was noticed. However, for the purpose of this experimental study, additional two sessions were also conducted (total 6). It was observed that their performance improved even further. All of them scored above 80 at the end of 4 sessions itself. The results obtained are as tabulated in table 5.3 below:

**Table 5.3 : Performance Chart of Ace Shooters (MarksMan) : Phase 2**

Performance Chart: MarksMan (M): 4-6 Sessions						
Module	No. of Shooters participated	Performance/ Score based distribution				Remarks
		Ex	G	AA	BA	
03	Shooters	80% & Above	60%-80%	40%-60%	Below 40%	No of Practice Sessions
<b>Grouping Distance</b>						
		$x \leq 1.5$	$2 \leq x < 1.5$	$3 \leq x < 2$	$x > 3$	

<b>Mod 1</b>						
03	03	--	--	--		After 02 sessions
<b>Mod 2</b>						
03	02	01	--	--		After 02 sessions
03	03	--	--	--		After 03 sessions
<b>Mod 3</b>						
03	01	1	1	--		After 02 sessions
03	02	01	--	--		After 04 sessions
03	03	--	--	--		After 06 sessions
<b>Mod 4</b>						
03	--	02	01	--		After 02 sessions
03	01	02	--	--		After 04 sessions
03	02	01	--	--		After 06 sessions

### Performance Analysis of Ace Shooters / Marksman (M)

Based on the analysis of above data, the following was observed:

- (i) Performance of Marksman shooters (participants) in Mods 1 & 2 has been observed to be exceptional. With minimal practise, they could achieve more than 90% score, that too, within 2 & 3 practice sessions in Mods 1 & 2 respectively. Thus, it can be said that, for Mods 1 & 2, with minimal practice, they could achieve their previous skill grade (M), same as that in static firing.
- (ii) For Mods 3 & 4, it was evident that, certain amount of training was necessitated to improve their firing skill. In the initial sessions, though they were hitting the target, they missed the 'bull'. However, quick improvement was noticed in their performance with successive training sessions such that they achieved scores of 80% & above within 4-6 practice sessions.
- (iii) By virtue of already being ace-shooters in static (Marksman), it was observed that they could adapt to this new system of moving targets, very easily and fast, i.e., within 2-3 sessions. The subsequent sessions, i.e., 3-6, were mostly utilised to further improvise their grouping skills.

#### 5.6.2 Phase-2: Good Grade (G) Shooters (of Static).

For G-grade shooters, field trials were conducted by ensuring that the same experimental conditions are maintained. Training (practice) sessions were conducted as planned, initially, for 04 practise sessions followed by another 02 sessions. The results of demonstrated performance at the end of 4<sup>th</sup> and 6<sup>th</sup> sessions were recorded. The results obtained are as tabulated in table 5.4 below:

**Table 5.4 : Performance Chart of Good Shooters (G): 4 - 6 Training Sessions**

<b>Performance Chart: Good Grade Shooters (G): 4-6 Sessions</b>						
<b>Module</b>	<b>No. of Groups participated</b>	<b>Performance/ Score based distribution</b>				<b>Remarks</b>
		<b>Ex</b>	<b>G</b>	<b>AA</b>	<b>BA</b>	
	<b>20 Groups</b>	80% & Above	60%-80%	40%-60%	Below 40%	<b>No of Practice Sessions</b>
<b>Grouping Distance</b>						
<b><math>x \leq 1.5</math>    <math>2 \leq x &lt; 1.5</math>    <math>3 \leq x &lt; 2</math>    <math>x &gt; 3</math></b>						
<b>Mod 1</b>						
	20	02	14	04	--	After 04 sessions
	20	2.5	16.5	01		After 06 sessions
<b>Mod 2</b>						
	20	1.5	13	5.5	--	After 04 sessions
	20	02	16	02		After 06 sessions
<b>Mod 3</b>						
	20	--	02	04	14	After 04 sessions
	20	0.5	3.5	07	09	After 06 sessions
<b>Mod 4</b>						
09 out of 20 groups could not qualify for Mod 4 due to BA grading in Mod 3						
	11	--	0.5	1.5	09	After 04 sessions
	11	--	1.5	03	6.5	After 06 sessions

**Performance Analysis of G-grade Firers: After 4-6 Sessions**

From the analysis of above data, the following was observed:

- (i) For Mods 1 & 2, performance of G-grade firers was quite encouraging. However, their learning/ grasp rate was observed to be lesser as compared to that of Marksman. For example, all 3 marksman (100%) achieved scores of 80 & above within 2 & 3 practice sessions for Mods 1 & 2 respectively; Whereas, in case of G-grade firers, even at the end of 4 practice sessions, only 10% of total firers (8 out of 80) could achieve a score of 80 & above.
- (ii) For Mod1, at the end of 04 sessions, only 70% (56 of 80) of G-grade firers could achieve scores between 60-80%, and thus could retain their previous grade (G), same as in static. This is far less, in comparison with marksman who could regain their previous grade (M), within 2-3 sessions, for the same Mods. Even at the end of 6 sessions, the percentage improvement of G-grade firers was only an additional 12.5%, i.e., total 82.5%. Similar pattern is observed for other mods too. That is, learning rate of Marksmen was observed to be higher than that of G-grade firers, across all modules. This observation is based on the reduced number of training sessions that were required by marksman as compared to that required for G-grade firers.

- (iii) It was also observed that the rate of incremental improvement in firing scores between 4<sup>th</sup> & 6<sup>th</sup> sessions is not uniform for all grades, and has been observed to gradually reduce with each successive module, i.e., with increasing degree of difficulty of target motion. It was also observed that the learning rate is different for different modules and also for different number of training sessions. The factors influencing the learning rate, and the way they affect the learning rate, etc is not in the scope of this study. Hence it was not researched further. Results of comparative analysis in terms of percentage of G-grade participants who scored G-grade (scores of 80 & above) in moving target firing at the end of 4 & 6 sessions is as tabulated in table 5.5 below:

**Table 5.5 :** Comparative Statistics: G-grade: After 4 / 6 Sessions

Mod	Percentage of participants who achieved G grade	
	After 4 Sessions	After 6 Sessions
1	80 %	95 %
2	72.5 %	90 %
3	10 %	20 %
4	2.5 %	12.5 %

- (iv) In case of Mod 3, at the end of 4 / 6 practice sessions, it was observed that the learning or grasping rate of the firers was lesser, as compared to their own grasping / learning rate in Mods 1 & 2. This was noted based on their firing performance. Thus, from analysis of results, it can be stated that degree of difficulty of predicting target motion, is indirectly proportional to the rate of grasp/ learning. That is, greater the degree of difficulty, lesser is the rate of learning / grasp. The same was confirmed by the firers too, during verbal interactions while conducting field trials.
- (v) For Mod 3, even at the end of 6 practice sessions, 36 out of 80 participants (45%) could not even score atleast 40%, and thus remained in BA grade. Hence, they could not qualify themselves for Mod 4, as per 'eligibility criteria' condition. Only the remaining 44 could qualify themselves to fire at Mod 4. Further, in Mod 4, at the end of 6 practice sessions, 26 out of 44 participants (54.5%) could not score atleast 40%. These results re-confirm and are indicative that, inspite of uniform conditions of training environment, learning / grasp rate is different for different modules for same grades of firers. The rate of learning is observed to be inversely proportional to degree of difficulty of target motion.

### 5.6.3 Phase-2: Above Average Grade (AA) Shooters (of Static)

For AA-grade shooters too, field trials were conducted by ensuring that the same experimental conditions are maintained. Training (practice) sessions were conducted as planned, initially, for 04 practise sessions followed by another 02 sessions. The results of demonstrated performance at the end of 4<sup>th</sup> and 6<sup>th</sup> sessions were recorded. The results obtained are as tabulated in table 5.6 below:

**Table 5.6 : Performance Chart of AA-grade Shooters: After 4-6 Training Sessions**

<b>Performance Chart: Above Average Grade Shooters (AA)</b>						
<b>Module</b>	<b>No. of Groups participated</b>	<b>Performance/ Score based distribution</b>				<b>Remarks</b>
		<b>Ex</b>	<b>G</b>	<b>AA</b>	<b>BA</b>	
	<b>11 Groups</b>	80% & Above	60%-80%	40%-60%	Below 40%	<b>No of Practice Sessions</b>
<b>Grouping Distance</b>						
		<b><math>x \leq 1.5</math></b>	<b><math>2 \leq x &lt; 1.5</math></b>	<b><math>3 \leq x &lt; 2</math></b>	<b><math>x &gt; 3</math></b>	
Mod 1	11	--	01	07	03	After 04 sessions
	11	01	02	08	--	After 06 sessions
Mod 2	11	--	01	05	05	After 04 sessions
	11	--	02	08	02	After 06 sessions
Mod 3	02 out of 11 groups could not qualify for Mod 3 due to BA grading in Mod 2					
	09	--	--	1.5	7.5	After 04 sessions
	09	--	--	03	06	After 06 sessions
Mod 4	06 out of 09 groups could not qualify for Mod 4 due to BA grading in Mod 3					
	03	--	--	0.5	2.5	After 04 sessions
	03	--	--	01	02	After 06 sessions

### **Performance Analysis of AA-grade Firers: After 4-6 Sessions**

From the analysis of above data, the following was observed:

- (i) For Mod 1, even at the end of 4 practice sessions, Nil could achieve scores of 80% & above. Further, even at the end of 6 sessions, only 04 out of 44 participants (9%) could score 80% & above. For all other Mods – 2, 3 & 4, NIL could achieve a score of 80% & above irrespective of 4 or 6 sessions. This is far less, for a similar comparison with good grade firers. This once again goes to prove that previous skill-grade of firers has a significant impact on the learning rate.
- (ii) The rate of learning, to gain A and G grades in various modules has been compared and the following has been observed:
  - (a) For any chosen grade of firers, their performance has been observed to gradually deteriorate from Mod 1 to Mod of in descending order. This is attributable to degree of difficulty in predicting the target motion.
  - (b) With increasing module, the deterioration/ drop in performance of AA-grade firers is comparatively higher w.r.t. G-grade firers (@Table 5.5). This is

attributable to previous skill level, before the training has started. These details are depicted in table 5.7 below:

**Table 5.7 :** Comparative Statistics: AA-grade: After 4- 6 Sessions

Total Participants	Percentage of AA-grade participants who achieved AA grade		Percentage of AA-grade participants who achieved G grade	
	After 4 Sessions	After 6 Sessions	After 4 Sessions	After 6 Sessions
<b>Mod 1</b>	73 %	100 %	09 %	27 %
<b>2</b>	54 %	91 %	09 %	18 %
<b>3</b>	13 %	27 %	00 %	00 %
<b>4</b>	4.5 %	09 %	00 %	00 %

- (iii) The above results are indicative of following observations with respect to rate of learning. Rate of learning is assessed/ measured in terms of the scores achieved by firers at the end of training sessions:
- Rate of learning for different grades of firers is different, irrespective of uniform training conditions.
  - Rate of learning is seemingly proportional to previous skill grade. That is, higher the skill grade in previous, better is the rate of learning and vice-versa.
  - Rate of learning drops (reduces) with increasing difficulty of target motion. This rate of drop is not uniform – for different grades of firers as well as for different modules.

It may be noted that the rate of learning, and the impact of various factors on rate of learning, is not part of scope of this research work. Hence this aspect has not been studied further deeper.

#### 5.6.4 Phase-2: Below Average Grade (BA) Shooters (of Static)

After completion of training and assessment of all other grades of firers, BA-grade firers were imparted practice training in the last. On completion of 4-6 sessions, their performance was recorded. The results obtained are as tabulated in table 5.8 below:

**Table 5.8 :** Performance Chart of BA-grade Shooters: After 4-6 Training Sessions

Performance Chart: Below Average Grade Shooters (BA)						
Module	No. of Groups participated	Performance/ Score based distribution				Remarks
		Ex	G	AA	BA	
	<b>05 Groups</b>	80% & Above	60%-80%	40%-60%	Below 40%	<b>No of Practice Sessions</b>
<b>Grouping Distance</b>						
		$x \leq 1.5$	$2 \leq x < 1.5$	$3 \leq x < 2$	$x > 3$	
	05	--	--	--	05	After 04 sessions

Mod 1	05	--	--	01	04	After 06 sessions
04 out of 05 groups could not qualify for Mod 2 due to BA grading in Mod 1						
Mod 2	01	--	--	--	01	After 04 sessions
	01	--	--	--	01	After 06 sessions
Mod 3	Nil qualified out of 5 groups for Mod 3 due to BA grading in Mod 2					
Mod 4	Not Applicable					

### Performance Analysis of BA-grade Firers: After 4-6 Sessions

- (i) Only 4 out of 20 participants (20%) scored 40 & above, even after 6 sessions and thus only those four qualified for next module, i.e., Mod 2.
- (ii) In Mod 2, the performance was even poorer, i.e, none could score atleast 40% even after completion of 6 sessions of training. Thus, None qualified beyond Mod 2.
- (iii) The rate of learning / grasp or adaptation has been found to be extremely poor as compared to other grade firers.

### 5.7 Experiments - Phase 3: Additional Training Sessions – upto 10 Sessions

From the demonstrated performance at the end of 6 practice sessions, it has been observed that, some of the firers, belonging to different grades, have failed to score even a minimum 40 %, for different modules, and thus failed to ‘qualify’ themselves for the next level. Hence, for experimental study purpose, additional 4 practise sessions, (totalling to 10) were given to only those firers, who failed to qualify to the next level, because they could not even score a minimum of 40% and hence remained in BA-grading even after 6 sessions. After imparting these additional 04 practice sessions (totalling to 10), performance of the firers was once again recorded. The summary of trails conducted, the results of performance recorded, their evaluation are all described in following paragraphs. It may be noted that the following groups/ participants have not been given these additional training sessions:

- (i) Marksman. Since all marksman have already achieved/ scored above 80% within 6 sessions, they have not been given this additional training of 04 sessions.
- (ii) G-grade Firers. Since all G-grade firers scored more than 40% in Mods 1&2, additional training sessions (upto 10) have not been carried out for these two Mods. However, additional training has been imparted for Mods 3 & 4 since there were firers who could not score atleast 40% within 6 sessions.
- (iii) AA-grade. Since all AA-grade firers scored more than 40% in Mod 1, additional training sessions (upto 10) have not been carried out for Mod1. However, additional training has been imparted for Mods 2, 3 & 4 since there were firers who could not score atleast 40% within 6 sessions in all three Mods.

#### 5.7.1 Phase-3: Good Grade (G) Shooters (of Static)

The prime purpose of phase 3 trials was to study the effect of additional training sessions (upto 10) to improvise firing skills, so as to score atleast 40% at the end of 10 sessions. Accordingly,

for G-grade firers, additional training sessions were provided only for Mods 3 & 4, maintaining the uniformity of training conditions. The summary of results obtained is as tabulated below:

**Table 5.9 : Performance Chart of Good Shooters (G): 10 Training Sessions**

<b>Performance Chart: Good Grade Shooters (G): 10 Sessions</b>						
<b>Module</b>	<b>No. of Groups participated</b>	<b>Performance/ Score based distribution</b>				<b>Remarks</b>
		<b>Ex</b>	<b>G</b>	<b>AA</b>	<b>BA</b>	
	<b>20</b>	80% & Above	60%-80%	40%-60%	Below 40%	<b>No of Practice Sessions</b>
		<b>Grouping Distance</b>				
		<b><math>x \leq 1.5</math></b>	<b><math>2 \leq x &lt; 1.5</math></b>	<b><math>3 \leq x &lt; 2</math></b>	<b><math>x &gt; 3</math></b>	
<b>Mod 3</b>	20	--	02	04	14	After 04 sessions
	20	0.5	3.5	07	09	After 06 sessions
	20	02	07	08	03	After 10 sessions
<b>Mod 4</b>	09 out of 20 groups could not qualify for Mod 4 due to BA grading in Mod 3					
	11	--	0.5	1.5	09	After 04 sessions
	11	--	1.5	03	6.5	After 06 sessions
Additional 6gps qualified (Total =17) into Mod 4 after 10 sessions of practice in Mod 3						
<b>Mod 4</b>	17	--	0.5	2.5	14	After 04 sessions
	17	--	3.5	5.5	08	After 06 sessions
	17	1.5	04	6.5	05	After 10 sessions

### **Performance Analysis: G grade: After 10 Sessions**

The details of performance analysis, at the end of 10 training sessions is below:

- (i) For Mod 3, after additional practice sessions, 24 more participants have qualified for Mod 4, totalling to 68 (earlier only 44). This is an increase by 30% (from earlier 55% @ 6 sessions to 85% @ 10 sessions); However, 12 participants of the total 80 (15%) could still not make it to Mod 4 inspite of 10 sessions.
- (ii) For Mod 4, after additional practice sessions, a total 48 (of 68) participants (70%) gained scores more than 40 vis-à-vis 18 (of 44) participants (41%), after 6 sessions, i.e., an increase of 29%.
- (iii) A comparative analysis of overall improvement in performance, at the end of 6 & 10 sessions, for Mods 3 & 4 is given in in tabular form in table 5.10 below:

**Table 5.10** : Comparative Analysis: G-grade: After 6 / 10 sessions

Mod	Ses Sions	Total Partici- pants	Gained AA & above	%age	Gained G & above	%age	Gained Ex	%age
3	6	80	44	55	16	20	02	2.5
	10	80	68	85	36	45	08	10
4	6	44	18	41 (22.5)*	10	22.7 (12.5)*	--	--
	10	68	48	70 (60)*	22	32 (27.5)*	06	8.8 (7.5)*

**Note:** (\*): Indicates percentage with respect to total participants (80)

- (iv) Based on above data, it could be said that the learning / grasp rate of G grade firers is directly proportional to the number of practice sessions. However, it was observed that, with increasing degree of difficulty of target prediction in successive modules, rate of learning has relatively reduced. The exact reasons for such phenomena has not been studied further since it was beyond the scope of this research work.

### 5.7.2 Phase-3: Above Average Grade (AA) Shooters (of Static)

In case of AA-grade firers, additional training upto 10 sessions was not conducted for Mod1, since all AA-grade firers, at the end of 6 training sessions, achieved AA grade or above (i.e., scored 40% & above) in Mod1. For Mod 2, at the end of 6 sessions, 08 out of 44 participants remained in BA-grade. Only 36 could qualify for Mod 3. After 6 sessions of practice in Mod 3, 24 out of these 36 participants remained in BA-grade. That is, only 12 participants (out of total 44) could qualify for Mod 4 training. In Mod 4, at the end of 6 sessions of training, 08 out of these 12 qualified participants could not score atleast 40 and hence remained in BA grade. With this background, additional 04 sessions of training (totalling to 10) were imparted to all participants in phase 3. The results obtained are as tabulated in table 5.11 below:

**Table 5.11** : Performance Chart of AA-grade Shooters: 10 Training Sessions

Performance Chart: Average Grade Shooters (A): 10 Sessions						
Module	No. of Groups participated	Performance/ Score based distribution				Remarks
		Ex	G	AA	BA	
	11 Groups	80% & Above	60%-80%	40%-60%	Below 40%	No of Practice Sessions
<b>Grouping Distance</b>						
		$x \leq 1.5$	$2 \leq x < 1.5$	$3 \leq x < 2$	$x > 3$	
Mod 2	11	--	0.5	5.5	05	After 04 sessions
	11	--	01	08	02	After 06 sessions

	11	0.5	01	9.5	--	After 10 Sessions
Mod 3	02 out of 11 groups could not qualify for Mod 3 due to BA grading in Mod 2					
	09	--	--	1.5	7.5	After 04 sessions
	09	--	--	03	06	After 06 sessions
Mod 4	06 out of 09 groups could not qualify for Mod 4 due to BA grading in Mod 3					
	03	--	--	0.5	2.5	After 04 sessions
	03	--	--	01	02	After 06 sessions
Additional 2 gps qualified (Total =11) into Mod 3 after 10 sessions of practice in Mod 2						
	11	--	--	02	09	After 04 sessions
Mod 3	11	--	--	04	07	After 06 sessions
	11	--	--	06	05	After 10 Sessions
Additional 3 gps qualified (Total =06) into Mod 4 after 10 sessions of practice in Mod 3						
Mod 4	06	--	--	0.5	5.5	After 04 sessions
	06	--	--	01	05	After 06 sessions
	06	--	--	02	04	After 10 Sessions

### Performance Analysis: AA grade: After 10 Sessions

The performance analysis of AA-grade firers at the end of 10 sessions is mentioned below:

- (i) By virtue of additional practice sessions for Mod 2, 08 participants have qualified additionally into Mod 3 from Mod 2. That is, earlier, at the end of 6 sessions only 36 participants out of 44 qualified for Mod 3. However, at the end of 10 sessions, all 44 participants qualified into Mod 3. Thus, it can be said that there is an increase of 18% (from 82% to 100%).
- (ii) Similarly, in case of Mod 3, after additional practice, 12 participants qualified additionally into Mod 4 from Mod 3. That is, earlier, at the end of 6 sessions only 12 participants out of 36 (total 44) qualified for Mod 4. However, at the end of 10 sessions, 24 of 44 qualified into Mod 4. Thus, an increase of 27.27% of firers (from 27.27% to 54.55%) is noticed. In other words, it can be said that, in case of Mod 3, at the end of 10 sessions there is 100% increase in number of participants who could score atleast 40 and qualify themselves to the next level.
- (iii) However, in case of Mod 4, Nil improvement was noticed even after additional training sessions. That is, total percentage of firers who could gain grade AA has remained constant at 33% (4 out of 12) in 6 sessions as well as in 10 sessions (8 out of 24)

### 5.7.3 Phase-3: Below Average Grade (BA) Shooters (of Static)

The performance of BA-grade firers in moving target firing has been observed to be relatively very poor even from phase-1, when compared with other grade firers. At the end of 6 sessions of practice in Mod 1, only 04 out of 20 participants qualified for Mod 2. Further, none could

qualify beyond Mod 2. Based on their performance till 6 sessions, it could be observed that, BA-grade firers were finding it difficult to cope up with skills required to fire at moving targets. However, for the purpose of this experimental trials, all 20 participants of BA-grade firers have been given 04 additional practice sessions, totalling to 10, similar to that of other grade firers. The performance analysis of BA-grade firers at the end of 10 sessions is tabulated in table 5.12 below:

**Table 5.12 : Performance Chart: BA-grade Firers: After 10 Training Sessions**

<b>Performance Chart: Below Average (BA) Grade Shooters: 10 Sessions</b>							
<b>Module</b>	<b>No. of Groups participated</b>	<b>Performance/ Score based distribution</b>				<b>Remarks</b>	<b>No of Practice Sessions</b>
		<b>Ex</b>	<b>G</b>	<b>AA</b>	<b>BA</b>		
	<b>05 Groups</b>	80% Above	& 60%-80%	40%-60%	Below 40%		
		<b>Grouping Distance</b>					
		<b><math>x \leq 1.5</math></b>	<b><math>2 \leq x &lt; 1.5</math></b>	<b><math>3 \leq x &lt; 2</math></b>	<b><math>x &gt; 3</math></b>		
Mod 1	05	--	--	--	05	After sessions	04
	05	--	--	01	04	After sessions	06
	05	--	--	1.5	3.5	After sessions	10
Mod 2	04 out of 05 groups could not qualify for Mod 2 due to BA grading in Mod 1						
	01	--	--	--	01	After sessions	04
	01	--	--	--	01	After sessions	06
Mod 3	Nil qualified out of 5 groups for Mod 3 due to BA grading in Mod 2						
Mod 4	Not Applicable						
Additional half gp qualified (Total =1.5) into Mod 2 after 10 sessions of practice in Mod 1							
Mod 2	1.5	--	--	--	1.5	After sessions	04

1.5	--	--	--	1.5	After sessions	06
1.5	--	--	--	1.5	After Sessions	10
Nil qualified for Mod 3 even after 10 sessions						

### Performance Analysis: BA grade: After 10 Sessions

Even after 10 sessions of practice, effectively Nil improvement was noticed in the performance of BA grade firers in any of the modules. Observing the pattern of results, it could be said that there is NO improvement (or very marginal improvement) in performance irrespective of number of firing sessions. This can be attributable to inherent limitations of these firers to learn (or improvise), by virtue of their low grade (BA), which was evident even during static firing gradation also.

## 5.8 Comparison of Performance of Firers Before and After Training

As a part of the experiments/ field trials, initially, before imparting any training on moving targets, performance of all firers, in terms of their demonstrated performance, has been noted (phase 1). Subsequently, after imparting 6 sessions of training, the performance of firers was tested and their performance noted (phase 2). Lastly, additional training of 4 more sessions, totalling to 10 sessions was imparted and their performance at the end of 10 sessions was once again noted (phase 3). Comparative performance of firers has been carried out between the initial and final stages, i.e. before commencement of training (phase-1) and at the end of ten sessions of training (phase-3). The details are as tabulated below in table 5.13.

**Table 5.13** : Comparative Analysis : Before & After Training on Moving Targets

Mod- Ule	No. Partici- pants (N)	Phase 1 (Without Training)				Phase 3 (After 10 Sessions)				Remarks
		Percentage of Participants based on their Scores Achieved				Percentage of Participants based on their Scores Achieved				
		Ex	G	AA	BA	Ex	G	AA	BA	
<b>Marks -men</b>										
M1	03	100	-	-	-	100	-	-	-	2 sessions
M2	03	100	-	-	-	100	-	-	-	2 sessions
M3	03	-	-	100	-	100	-	-	-	4 sessions
M4	03	-	-	100	-	66.6	33.3	-	-	6 sessions
<b>Good Grade</b>										
M1	80	-	70	30	-	12.5	82.5	05	-	6 sessions
M2	80	-	15	85	-	10	80	10	-	6 sessions
M3	80	-	-	-	80	10	35	45	15	
M4	80	-	-	-	63.75	7.5	20	32	25	
<b>Above Avg</b>										
M1	44	-	6.8	34.1	59.1	9.1	18.2	72.7	-	6 sessions
M2	44	-	-	-	100	4.5	9.1	86.4		
M3	44	-	-	-	43.2	-	-	54.6	45.4	
M4	44					-	-	18.2	36.4	

<b>Below Avg</b>									
M1	20	-	-	-	100	-	-	30	70
M2	20	-	-	-	60	-	-	-	20
M3	20	-	-	-	-	-	-	-	-
M4	20	-	-	-	-	-	-	-	-

From the above table it is evident that :

- (i) There is an apparent improvement in the performance in terms of scores achieved by participants (trainees) before and after training. This has been observed to be similar for all grades of firers, in all modules, except for BA-grade firers.
- (ii) The degree of improvement in scores by virtue of training imparted is observed to be different for different grades of firers, even though training conditions were maintained uniform for all participants through-out.
- (iii) Further, it is clearly noticeable that performance of firers is largely influenced primarily by two factors - degree of difficulty of target motion and previous skill grade (proficiency) of firers. This observation assumes significance in the context that training has been conducted in uniform conditions for all.
- (iv) In case of BA-grade firers, very minor improvement in performance was noticed in module 1. For module 2, even after 10 sessions, only negligible improvement was noticed. Further, none of the BA-grade firers could even score a minimum of 40 and thus could not qualify for modules 3 and 4. This once again goes to validate the hypothesis that previous skill grade in static firing has significant effect on learning / performance in moving targets.

Hence, the results of the experiment (training) were evaluated from two major perspectives; first, “is there any impact of ‘increment in difficulty level’ of target movement on the scoring of the trainees?” and second “is there any impact of ‘initial proficiency level’ (in static training) on the learning pattern of trainees?”. To understand these aspects, scores achieved by participants (score-based percentages) after each phase (both, phase 2 and 3) of training were plotted against their initial scores recorded in phase 1 (before training). This was carried out in respect of all four modules. Data thus obtained was initially analysed from first perspective, i.e., to analyse the effect of degree of difficulty of target movement on scoring by participants. For this, the results obtained by all shooters, of all grades, were compared for each module. Similarly, in order to analyse results obtained from second perspective, i.e., to analyse the effect of the initial proficiency level in static training on scoring, the results of all four grades of shooters were compared for all four modules. The analysis carried out is depicted in the form of bar charts as shown below. The X-axis of these bar charts represents percentage distribution of participants, as per their scores achieved. The Y-axis represents percentages of scores achieved. For ease of assimilation, the following nomenclature was used in the bar charts:

X-Axis: Phases of Training

Phase 1 - Before Training

Phase 2 - After 6 Sessions

Phase 3 - After 10 Sessions

Y-Axis: Scores Achieved

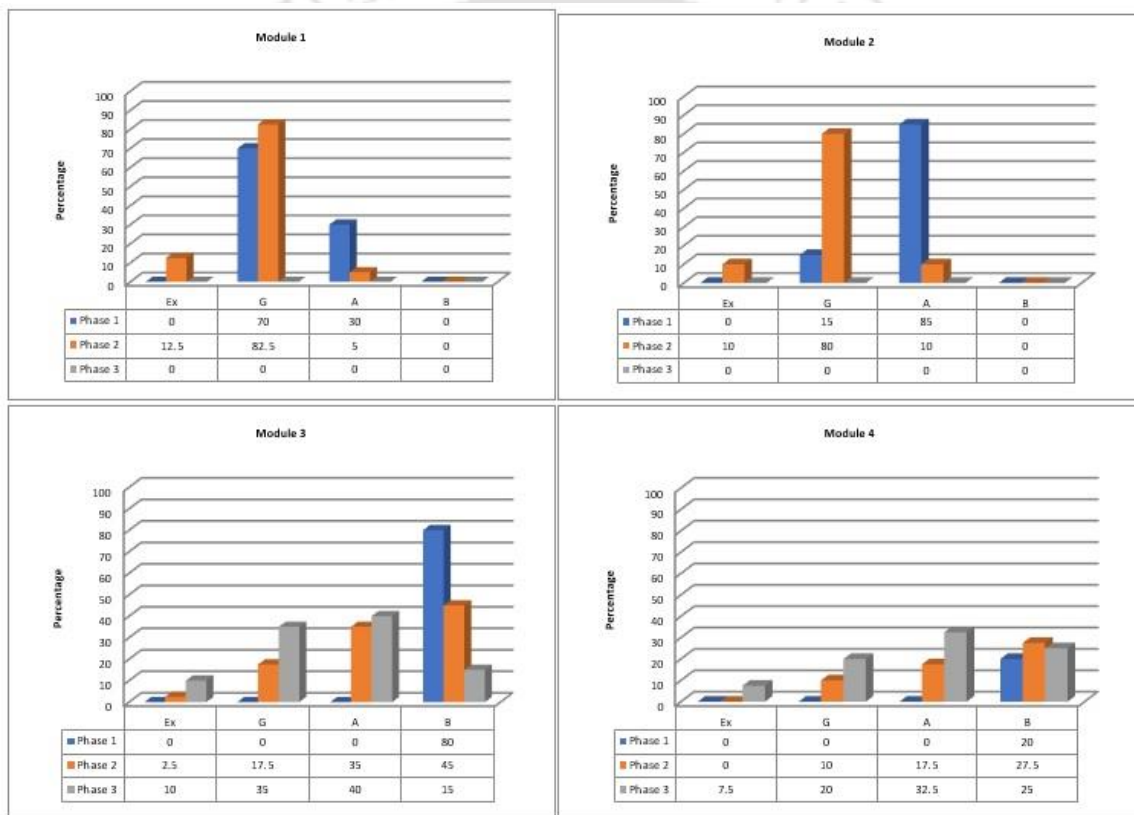
Ex Scores above 80

G Scores between 60 to 80

G Scores between 60 to 80

B Scores below 40

As known, there are four grades of firers – Marksmen, Good grade firers, Average Grade firers and Below Average grade firers. Hence, for each grade of firers, four charts are prepared, each representing progress in each module (total 4 Mods).



**Figure 5.1:** Results of 3 phases training on 4 different modules for “Good” (N-80) shooters

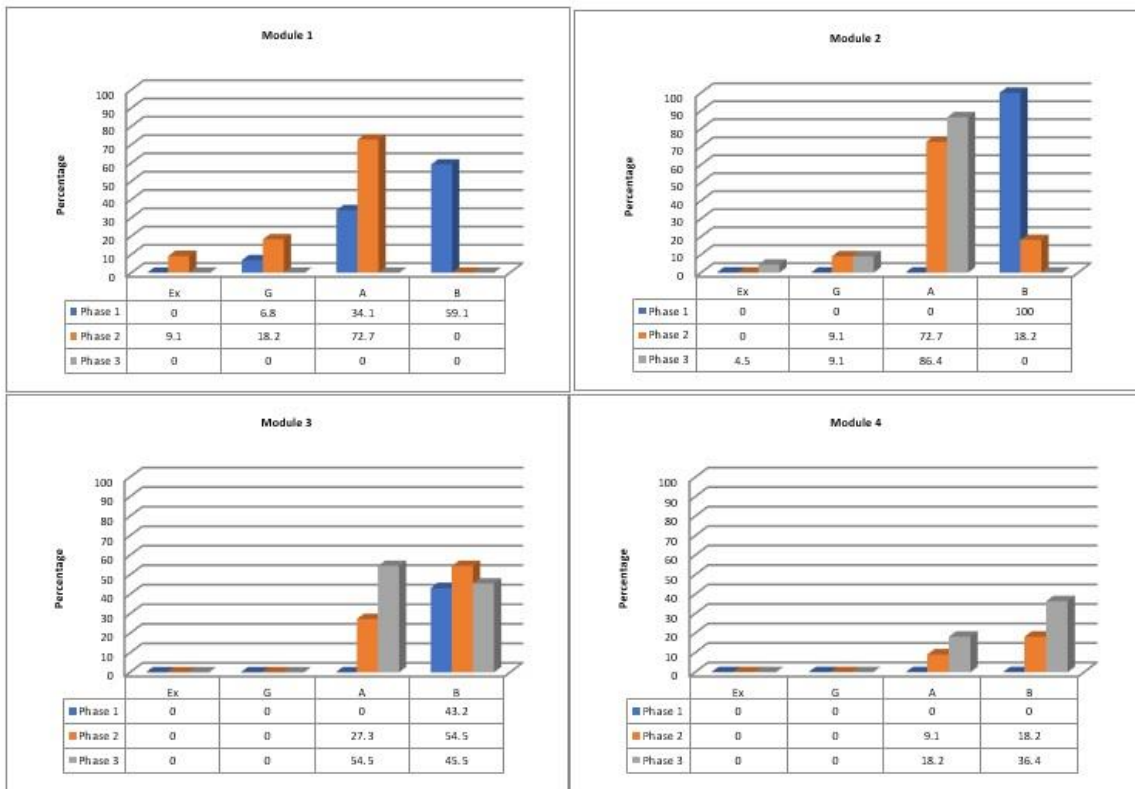


Figure 5.2: Results of 3 phases training on 4 different modules for “Average” (N-44) shooters

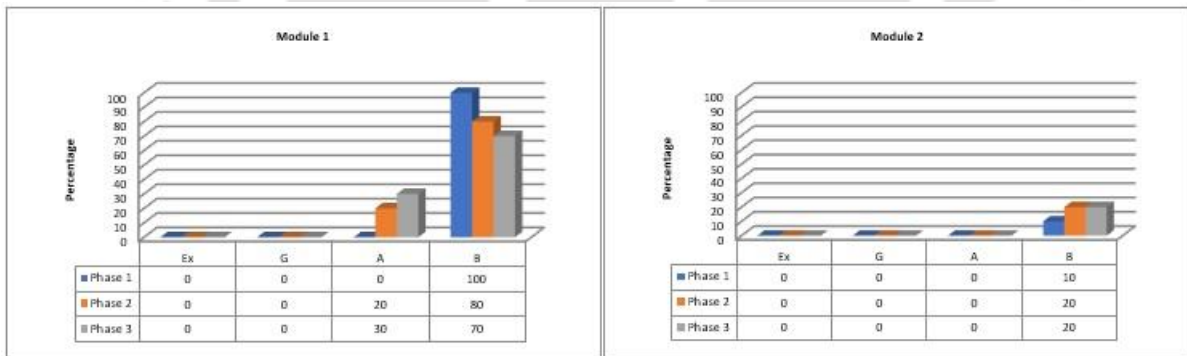
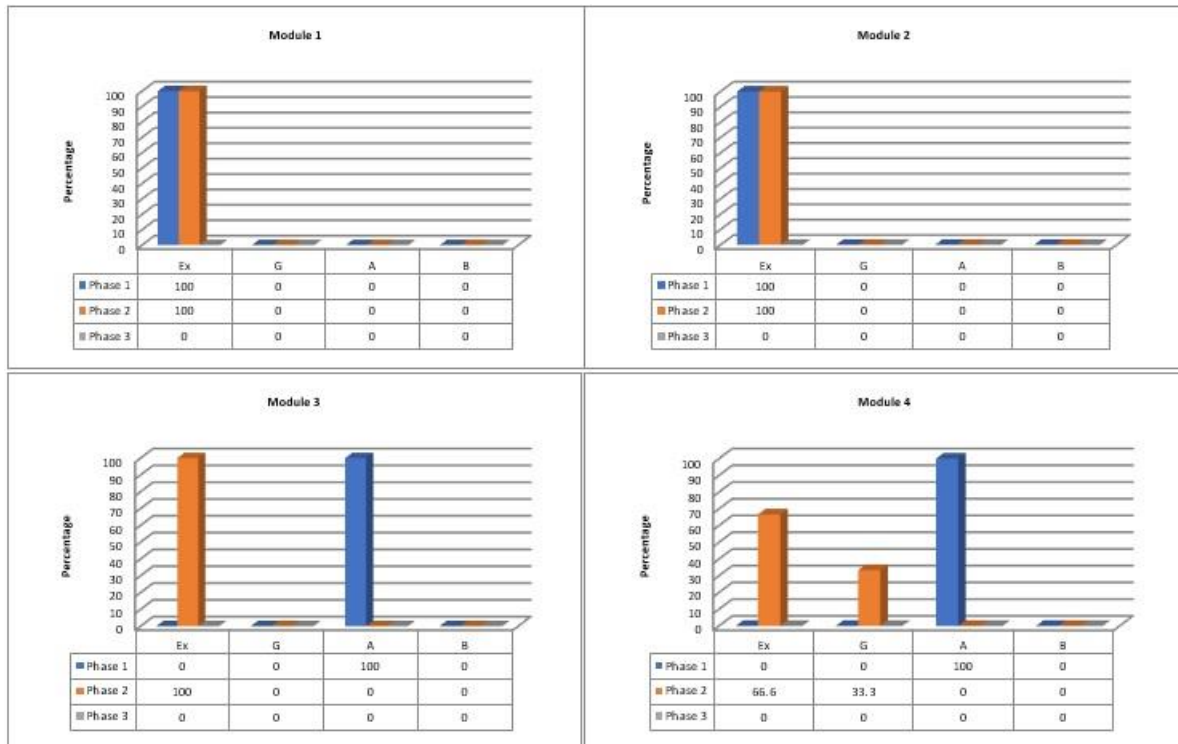


Figure 5.3: Results of 3 phases training on 4 modules for the “Below Average” (N-20) shooters

Note:

Below Average Grade Participants could not get eligible for Mod 3 & Mod 4; Hence plotting is not available for Mods 3 & 4



**Figure 5.4:** Results of 03 phases training on 04 different modules for “Marksman” (N-3) shooters

Note:

Phase 3 in all charts is ‘zero’ since phase 3 was NOT (required to be) conducted for marksmen in any of the four modules.

From the above charts, there is an apparent improvement in performance of each grade of firers, i.e., Good grade, Average grade, Below Average grade and Marksmen, for all four modules; which was evident in the table 5.13 as well. Even though the quantum of improvement noticed is different for different grades of firers and for different modules, one important observation is that ‘definite improvement’ in all grades of firers, in all modules. The only exception is the below grade (BA) participants who could not qualify themselves for modules 3 & 4, inspite of ten sessions of training. Further, it can also be easily noticed that quantum of improvement for any given grade of firers has progressively reduced with each increasing module. For example, if we consider the case of good grade firers, the quantum of improvement in performance after training is observed to be more in Mod 1 and gradually reduces with increasing module (degree of difficulty of target motion). Similar pattern is observed for other grade firers also. Thus, it can be stated that degree of difficulty of target motion has significant impact on improvement in performance.

Further, to analyse from second perspective, i.e., to understand the impact of initial proficiency level (static) on learning/ improvement in performance of moving target, following graphs are plotted in which for each module, performance of all four grades of firers was compared. Module wise bar charts plotted are as depicted below.

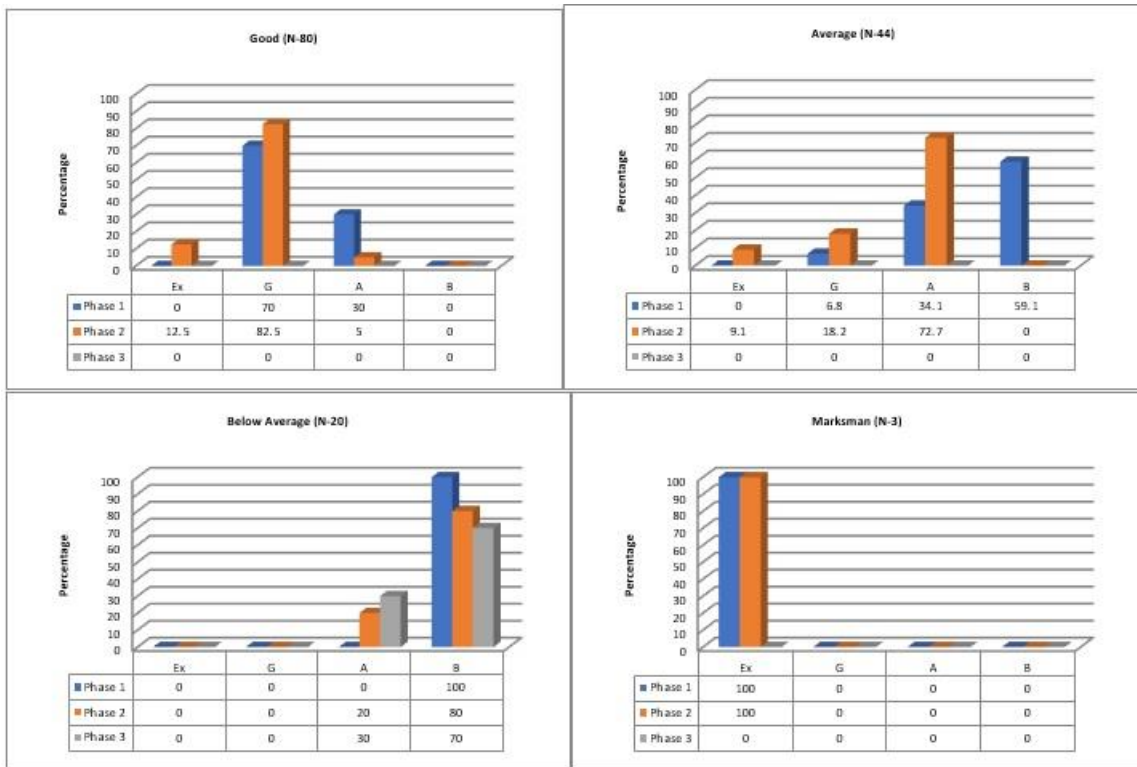


Figure 5.5: Performance of different grades of firers in Module 1 during all phases of training

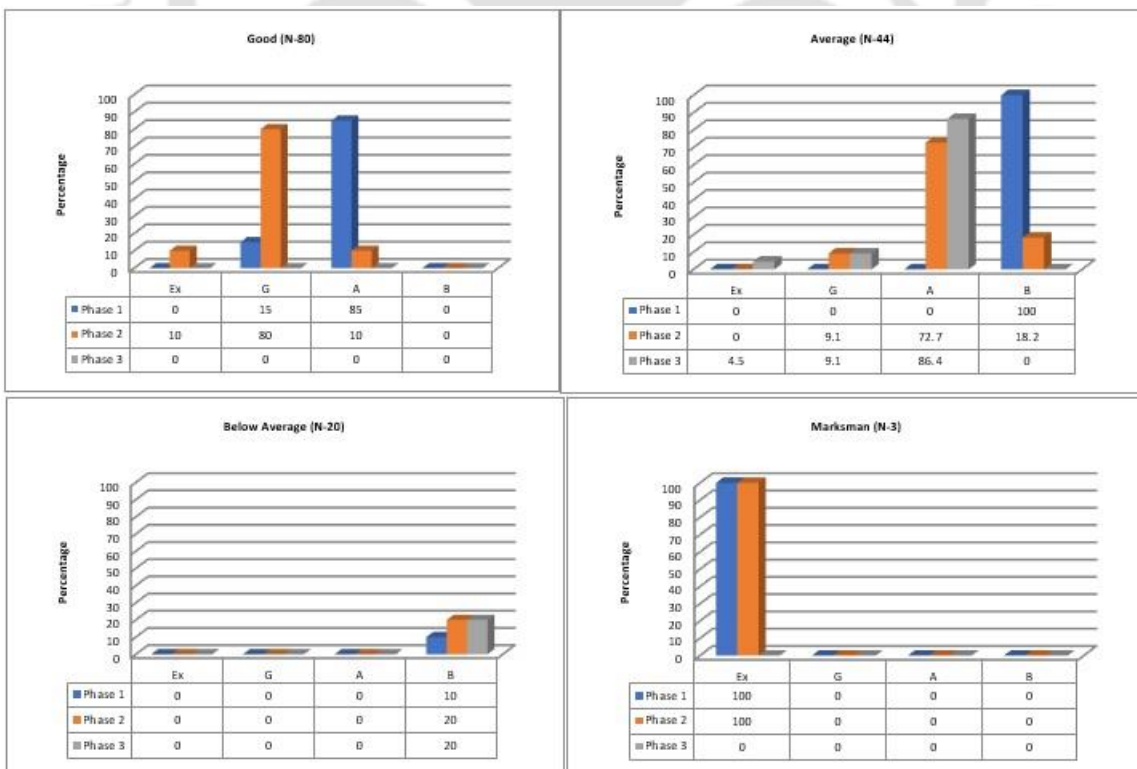
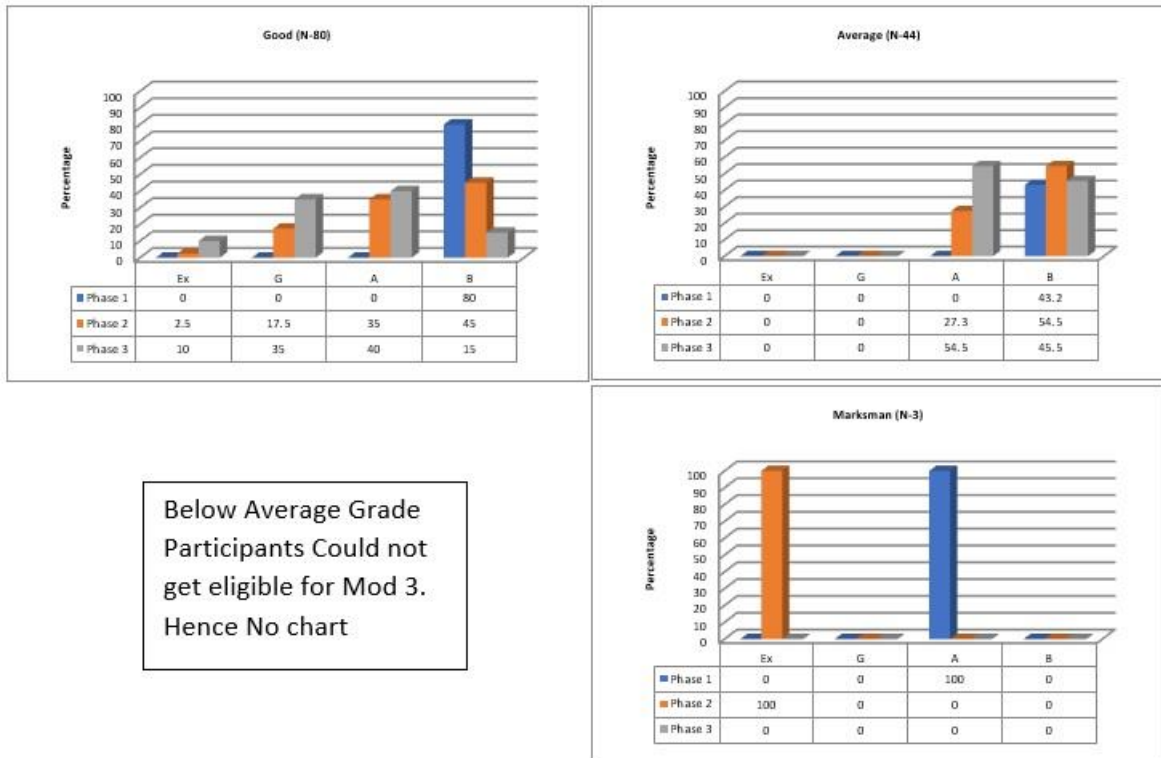
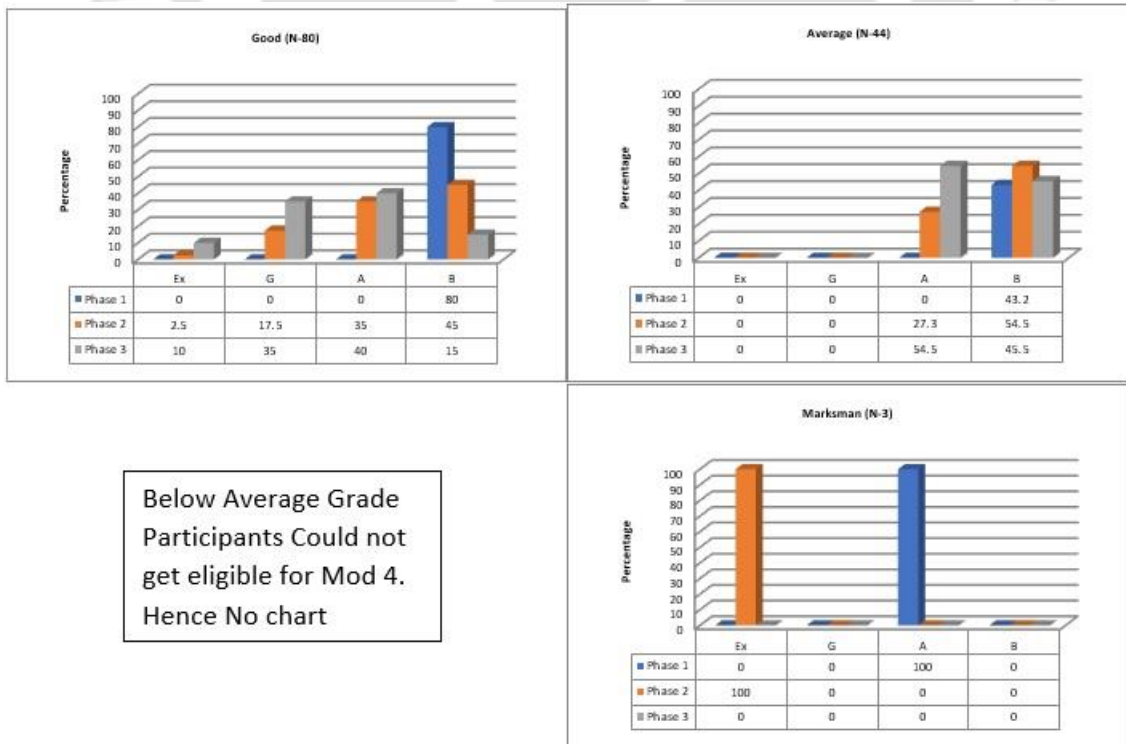


Figure 5.6: Performance of different grades of firers in Module 2 during all phases of training



**Figure 5.7:** Performance of different grades of firers in Module 3 during all phases of training



**Figure 5.8:** Performance of different grades of firers in Module 4 during all phases of training

From all of the above charts, it is clearly evident that initial proficiency (in static) has a direct bearing on improvement in performance on moving targets. The plotted graphs clearly depict that for any/ every module, the 'quantum of improvement in performance' is relatively more in marksman as compared to that of G-grade firers, which in turn is better than that of AA-grade firers. The improvement in performance of BA-grade firers is the lowest (not much) inspite of uniform training conditions.

Based on analysis depicted through all of the bar charts above, as well as table 5.13, it can be said that, both, i.e., either from the perspective of performance of a particular grade of firers in different modules or from the perspective of module wise performance of different grades of firers, apparent improvement (in performance) is noticed, before commencement of training and at the end of ten sessions of training, for all grades of firers. Hence, based on the experiment results obtained, it can be conclusively stated that the proposed training methodology through newly conceived method is significantly effective to improvise firing efficiency on moving targets.

## **5.9 Evaluation of Experiment Results & Overall Analysis**

Field trials were conducted as planned. All 144 participants have been imparted training/ practice in uniform conditions and their performance was recorded at the end of 4<sup>th</sup>, 6<sup>th</sup> and 10<sup>th</sup> sessions. Performance analysis was done at every stage to understand various aspects that influence this moving target training. The summary of analysis of field trials, is broadly divided into two categories as below:

### **5.9.1 Analysis of Results with respect to Imparting of Training**

- (i) The performance of Marksman has been better than any other grade firers in all modules. The term performance is used to represent the scores achieved by firers in different modules after being imparted proposed training on moving targets. Similarly, the performance of G-grade firers is observed to be better than that of AA-grade firers, which in turn is better than that of BA-grade firers. Thus, it can be concluded that previous skill grade (static) has a significant influence on the subsequent learning and performance (on moving targets). It has been observed that, better the firing skill on static targets, better the performance on moving targets.
- (ii) As seen from the results, marksman gained Ex grade (score of 80 & above), in 2 sessions for Mod1, 3 sessions for Mod 2, and after 6 sessions for Mods 3 & 4. However, for rest all other grades of firers, it has been observed that this rate of grasp / learning significantly reduced, based on two reasons. One, with decreasing previous grade (static firing) of firers. Second, with increasing degree of difficulty of Mods, i.e. target predictability
- (iii) Rate of learning in terms of number of firing (practice) sessions has also been observed to be indirectly proportional to previous skill grade. That is, if skill grade (in previous) is higher, number of training sessions required are noticeably lesser, (Eg: Marksman vis-à-vis any other grade of firers).
- (iv) For the same grade firers (any grade), the performance has been observed to deteriorate with each progressive module, i.e, with increasing degree of difficulty of target motion. Further, the quantum of deterioration in performance with each progressive module is

observed to be to apparently inversely proportional to skill grade achieved in previous. For example, if the drop in performance from Mod 2 to Mod 3 is taken as reference, the drop in performance for Marksman (from Mod2 to Mod3) is less, as compared to the drop in performance of G- grade firers for same modules, which in turn is less than the drop of AA-grade firers. That is, higher the skill grade, lesser the drop in performance.

- (v) From the overall data, it can be concluded that a minimum of 06 sessions is necessary to notice considerable improvement in firing skills on moving targets, i.e., to enable majority of the trainees to score a minimum of 40%. A significant further improvement is seemingly possible (feasible) with 10 sessions of firing. However, this phenomenon is not applicable to BA-grade firers, who have been observed to be NOT able to cope up with moving target skills irrespective of number of training sessions.
- (vi) It was observed that ‘learning rate’ of firing skills by various grades of firers was NOT directly proportional to the number of practice sessions, but was influenced by a combination of factors in which previous skill grade of firer and degree of difficulty of target motion have been observed to be very prominent. However, the exact co-relation between these factors has not been studied further, since it was out of scope for this research work.
- (vii) From the overall analysis of performance data, it can be said that, the proposed methodology to impart training on moving targets in a progressive sequence, has been observed to be ‘effective’, which was noticeable in the form of progressive improvement in the results of firers. Thus, the proposed methodology to impart moving target training through the fabricated model can be considered as an ‘effective training tool (aid)’ to improve firing efficiency on moving targets
- (viii) Verbal feedback obtained from firers who participated in the evaluation trials, from time to time, during conduct of various practice sessions, matched with all of the above conclusions. The gist of verbal feedback obtained is as given below:
  - (a) The fabricated model (prototype) developed is very safe and user friendly in terms of assembly or dis-assembly as well as for operation.
  - (b) The proposed methodology with four different types of modules for different types of motions is very novel & unique method to impart moving target training in existing open field ranges.
  - (c) The gradual increase in degree of difficulty to track target motion with each successive module has served as a positive challenge / motivator for firers to improve their firing efficiency.

### **5.9.2 Effectiveness of working model**

- (i) The fabricated model developed for generating four different types of target motions with the help of chassis and four independent modules has been observed to be successful in generating all four types of motions without any hiccups. The model has been observed to be rugged, yet easy to handle / operate. It was also noted that it confirms to all standard safety norms applicable in respect of a firing zone and hence safe to operate. Thus, it can be stated that, the fabricated model is highly satisfactory in its intended function.
- (ii) Field trails constituted frequent assembly & dis-assembly of various modules, safe storage & transportation of dis-assembled accessories, operations (movement of modules), maintenance activities, and other related activities. All these activities have

been observed to be performed as per SOPs formulated. Field trials validated that SOPs formulated are accurate, comprehensive, un-ambiguous and very practical.

### 5.9.3 Overall Analysis

Based on the performance analysis of various grades of firers in various modules, the initial hypothesis that ‘firers with lower skill grade in static firing are not likely to perform or stand less chance to perform, even in moving target firing’, is validated through field trials. Alternately, it is also proven that firers with better skill grade in static firing are likely to grasp and perform better on moving targets also is validated. Experiment results have amply proven and validated that proposed training methodology using the newly conceived cost-effective fabricated model is highly satisfactory & effective. Thus, it can be stated that, the proposed methodology of training on moving targets is ‘effective’ in improving the firing skills of firers. From the Ergonomics point of view, the proposed design does contribute significantly in terms of improvement in soldiers’ firing efficiency on moving targets, through improved man-machine interaction, imparted through proposed training methodology.



## CHAPTER 6: Summary and Conclusion

The aim of current research study was to design, fabricate and establish the effectiveness of the proposed training method to impart moving target training, in order to improve moving target firing skills of uniformed personnel (soldiers & police), especially of those, who do not have access/ exposure to moving target firing through simulation softwares. World over, modern day security concerns are deeply associated with suicide styled terror attacks. Though Special Forces or Commandos, (known by different names in different countries), are well-trained to tackle and nullify these threats, an important aspect is that, whenever such attacks occur, the Special Forces take/need considerable time to reach to the scene of attack. Till that time, the front-line foot soldiers (police included), i.e., the forces deployed on patrol duties or check-post duties, are the first to bear the brunt of such attacks. In this context, these soldiers of the first line of defence are required to possess adequate firing skills, especially on moving targets (attackers), so that they are prepared/ capable to effectively retaliate and thus thwart such attacks or at-least resist such attacks till the time Special Forces arrive.

In general, moving target training for soldiers can be imparted in two distinct methods. One, through physical means, in an open firing range, using huge infrastructure and specific mechanisms to generate various types of motions. This system is space consuming as well as cost-centric. Second method is through simulation softwares, which can generate different types of target movements, through software program codes. The softwares are expensive, especially when simulation resembles battle-like conditions. Thus, both types of training methods, i.e. physical methods as well as simulation techniques, are affordable by affluent/ technologically advanced countries only. In all other cases, i.e., in case of the under-developed & developing countries, owing to their financial & infrastructural limitations, weapon firing training for front-line foot soldiers (first line of defence) is largely limited to static target firing, in conventional open firing ranges. Except for the Special Forces, majority of the first-line defence forces of these countries are not exposed to moving target training (MTT) at all. Whereas, in an ideal scenario, considering modern days' security scenario, it is desirable that MTT be imparted to all security personnel (first line of defence), so that they are competent enough to fire at moving targets, which in turn translates into their 'better preparedness' to retaliate terror attacks more effectively. Feedback obtained through a preliminary survey of weapon training institutes also ratifies the same. Further, MTT to security personnel shall also enhance their deterrence value.

This research study was undertaken to explore most feasible method (as well as cost-effective) to impart training and improvise the firing skills of front-line soldiers (& police) on moving targets, using existing infrastructure (open firing ranges). This training is expected to improve their 'preparedness' to handle modern day terror attacks more effectively. The focus was on security personnel of the first line of defence because, they are the ones' who got to bear the brunt of such attacks first, even before and/ or till the time Special Forces can arrive. In earlier chapters, all the objectives that had been formulated at the initial stage of the research have been accomplished. The newly developed MTT method has the following distinct features:

- (a) This is a unique training model of its kind, associated with weapon firing training, on moving targets, using conventional infrastructure - open firing ranges.

- (b) For all those countries whose troops (soldiers & police) do not have access/ exposure to MTT on simulation softwares, this proposed method is considered an effective way to improvise their firing skills on moving targets. Also, this model is cost-effective and hence is considered as a potential method to impart moving target training, without dependence on highly expensive simulation software/ infrastructure that is otherwise needed to impart training on moving targets as per existing methods.
- (c) All spares, accessories and raw materials used to fabricate the model are sourced from commercially available stores/ supplies. This was a well-considered decision, to ensure ease of availability of requisite spares for repairs & replacements, in-order to minimize down time.
- (d) The model is user-friendly, easy to operate as well as to maintain and effective training tool to impart moving target training within available resources (open firing ranges)

**Note:** Since, the research study is carried out in India, certain aspects of proposed training method may appear to be influenced by/ matching with Indian conditions. However, the solution offered to impart/ improve moving target firing skills through the proposed physical model is implementable in any standard open firing range, under specified conditions as mentioned.

## 6.1 Learning & Contribution of this Research Work

This thesis work is focussed to suggest suitable ways to improve firing skills of soldiers (& police) on moving targets so that this skill helps them to effectively retaliate modern days' terror attacks. Through this research work, the following issues have been learnt/ established:

- (i) Effective ways to counter terror attacks has gained significance across the globe, in the recent decades. When a terror attack happens, Special Forces (SF) do take/ need some time to reach to a terror-attack site, to nullify the attack or control the situation/ damage. Thus, in such situations, security forces (defence as well as police personnel), deployed as first line of defence, are inevitably the first to bear the brunt of such attacks. Hence, their weapon firing skills (on moving targets) has a significant deterrence value and shall influence the outcome of such engagements. In this context, it can be said that, moving target training (MTT) is an important aspect of training to 'prepare' security forces of first line of defence, to counter such attacks more effectively.
- (ii) World over, moving target training is imparted by two distinct methods. One by Simulation techniques. Second by physical means.
  - (a) Simulation softwares can generate different types of target movements through program codes. Battle-like realistic conditions can also be simulated. However, these benefits come at a premium cost. Owing to affordability issues, MTT by simulation has been adopted only by rich/ developed countries such as USA, Russia, France, UK, etc. For all other under-developed & developing countries, owing to budgetary constraints, weapon firing training of their troops (soldiers

as well as police) is largely limited to conventional methods of training only i.e., training in open firing ranges.

- (b) In conventional means, generating different types of target motions physically has inherent limitations. First, each type of target motion requires a specific mechanism, which cannot be used to generate any other type of motion in that design/ configuration. Second, these mechanisms are not interchangeable. Thirdly, each mechanism is static by its conventional design and hence requires its own firing range. Thus, if there are three different types of motions that need to be generated, then, they require three different ranges, one for each, independently. Thus, this method also is cost-centric as well as needs physical space. With these practical limitations, firing training of troops of under-developed & developing countries is largely focussed/ limited to static target firing only.
- (iii) Feedback from preliminary survey of weapon training Institutes reiterated the fact that moving target training at training stage to all personnel of first line of defence shall be useful to enhance their 'preparedness' to counter terror attacks more effectively, and in turn, improve the overall deterrence value.
- (iv) In the backdrop of these aspects, the need to impart MTT in order to enhance firing skills on moving targets has been established. The challenge was to device/ design a cost-effective method to impart MTT such that it can be imparted on existing open firing ranges, thus avoiding the need for additional infrastructure, which is conventionally required in the conventional systems.

Based on the above, through this research work, a training model is designed to impart MTT using conventional open firing ranges. Prior to designing the model, the proposed content of training (training syllabus), has been formulated. Requisite training schedule for proposed training as well as skill assessment criteria to evaluate improvement in firing skills have also been worked-out, which are all considered as contributions of this research work. The broad details of each of these aspects is described below:

- (i) Data from various terror attacks, globally, in the past 15-20 years has been analysed to study the pattern of movements of attackers' and in turn deduce the 'content of training'. Accordingly, it has been established that moving target training is to be imparted on four different types of target movements:
  - (a) Horizontal motion
  - (b) Slant motion
  - (c) Flash Appearance & Disappearance of target
  - (d) Random motion of target.
- (ii) Designs (2D-drawings) for models to generate all four types of target motion have been progressively finalised, starting from rough sketching stage to conventional 2D representation.

- (iii) Based on the design-drawings, the working model has been fabricated, with compliance to following major concerns:
- (a) The materials used for fabrication are ensured to be ricochet compliant.
  - (b) The materials used are light in weight, yet strong enough to bear requisite load.
  - (c) The working model is designed such that, apart from target, ideally nothing is (should be) visible in target area. In the proposed design, it has been ensured that very minimal portion of the ‘construction’ is visible in the target area apart from the target, for all four modules.
  - (d) The model is all-weather operable, easy to assemble/ dis-assemble, without the need for any complex tools or mechanisms
  - (e) The spares used are available through commercial sources, so that replacements are readily available, in case necessary
  - (f) The developed model consists of a chassis and four independent modules (Mods), each capable to generate one particular type of motion. Accordingly, the module for horizontal motion is named as Mod-1, module for slant motion is named as Mod-2, Flash Appearance & Disappearance as Mod-3 and Random motion as Mod-4. The numbering is also suggestive of the degree of difficulty to predict target motion, i.e., higher the number, more the difficulty.
- (iv) Existing training schedules to impart static target training have been studied in detail. Based on this, and also based on certain conditions specific to moving target training, a training schedule has been formulated to impart MTT. Salient aspects are:
- (a) Progressive Training.  
Based on the established learning norms, MTT has been planned on similar lines, to be imparted progressively. That is, initially, MTT shall be imparted on relatively easy-moving targets, i.e., horizontal motion. Gradually, as the firers get acquainted and gain experience, they shall be given exposure/ practice on relatively difficult degrees of target motion.
  - (b) Eligibility Criteria.  
Adequate Skill in Static target firing has been fixed as eligibility criteria, whether or not to allow a trainee to undertake MTT. Similarly, for each upgradation, i.e., from Mod-1 to Mod-2 or from Mod-2 to Mod-3 (& so on), a pre-condition has been set that unless a firer achieves certain minimum score, he shall not be considered eligible to be upgraded to next level.
  - (c) Quantum of Training.  
Similar to the existing norms in vogue, each trainee is planned to be imparted MTT for 4-6 sessions, upto a maximum of 10 sessions. Each session consists of 04 spells, where, each spell is equivalent to 5 shots fired while the target moves from one end to the other.
- (v) ‘Accuracy’ and ‘Grouping’ have been the standard criteria to assess one’s firing skill. Based on a combined score, as per the current conventional norms, an individual’s performance is graded as Good, Above-Average or Below-Average. Certain practical constraints have been identified in the current gradation system in vogue. A modified

gradation system has been formulated, addressing/ resolving the constraints identified. The proposed skill assessment system has five gradations - Marksmen, Excellent, Good, Above-Average & Below-Average. This proposed system has two distinct advantages. First, it segregates firers based on their grouping skill. Second, the gradations are likely to serve as motivators for individual firers to upgrade themselves.

- (vi) Finally, in the last phase, field trials have been planned to be conducted, to validate the suitability of the model and training methodology to impart MTT and improve firing skills on moving targets. Before trials, the skill level of all firers has been noted. On completion of practice/ training, skill level was once again measured. This was conducted for all four modules. The participants were selected based on 'Stratified Random Technique', representing proportionate sampling of various groups in the total population.
- (vii) The field trial results are quite encouraging. Following are salient outcomes:
  - (a) Field trials have proven that methodical training on moving targets as proposed has a significant influence in improving the skill of firers on moving targets.
  - (b) Previous skill grade of firers on static targets has its influence on quantum of learning/ improvement in moving target firing
  - (c) Degree of difficulty of target motion has an inverse effect on learning/ performance of firers
  - (d) The quantum of learning (as measured by skill demonstrated) is proportional to number of training sessions (quantum of training) imparted. However, depending on conditions, and beyond a point, the amount of training has no direct/ proportionate effect on quantum of improvement. The major factors influencing these conditions are previous skill grade of firer and degree of difficulty of target movement.
  - (e) The conceived method to generate four different target motions physically on a moving chassis, with the help of four independent modules has proven to be successful.
  - (f) Field trails also established validity of certain design features incorporated such as compliance to safety norms, ease of operability, ruggedness of construction, user-friendliness, easy to assemble & dis-assemble, etc.
  - (g) Through the field trials, various SOPs developed for conduct of safe operations, maintenance, and storage (cum transportation) of MTT modules have also been verified to be practical, user-friendly and effective.

In total, the proposed model to impart MTT to soldiers (& police), especially those who do not have access/ exposure to MTT through simulation techniques, has proven to be successful, to improve firing skills on moving targets, using conventional infrastructure – open firing ranges. Based on satisfactory results of the trials conducted, it can be reasonably stated that proposed system of MTT has the potential to improve firing skills of troops on moving targets and in turn contribute in improving their 'preparedness' to counter any terror attacks in future more effectively and thus enhance their 'deterrence' value.

## 6.2 Limitation and Scope for futuristic studies

Following are some of the limitations, which also serve as potential scope for futuristic studies:

- (i) From the experiment results, it has been established that the rate of learning for different grades of firers has been observed to be different (varying), and is significantly impacted by two major factors – degree of difficulty in target motion and initial skill grade of firers. In other words, it has been observed from experiment results that, for a given amount of training, different grades of firers have different rates of learnings and for different modules. That is, for a given/ chosen module, the rate of learning is different for different grades of firers. This rate, varies again with different modules. The exact co-relation between grade of firers, number of practice sessions, degree of difficulty (of target motion) and learning rate (improvement in performance) has not been studied in detail, since it was out of scope for the present research work.
- (ii) The working model developed has a provision to vary the speed of target travel with the help of step pulleys and a suitable speed reduction mechanism incorporated in the system. However, for the purpose of experiment, single speed was used to conduct trials. Hence, as a futuristic scope, the effect of variation speed of target travel, on the rate of learning, can also be studied, firer-grade wise and /or module wise.
- (iii) The trials have been conducted with the firer in reasonably stable condition and comfortable environmental conditions. As a scope for futuristic studies, further experiments may be carried out to study the effect of certain factors listed below, on the rate of learning:
  - (a) Effect of dim light or dark conditions or harsh weather conditions.
  - (b) Effect of physical exhaustion (prior to firing) on performance of participants.
  - (c) Effect on performance of participants in the presence of simulated cross-fire, where the firer (participant) is required to duck / save himself while he continues to fire at moving targets – a more realistic version of battle-like conditions.

## 6.3 Conclusion

Amongst various security concerns of modern days, terror attacks are one of the major concerns for many countries across the world. Conventionally, armed forces (defence) are responsible to protect a country from external threats where as police forces are responsible to ensure internal peace and law & order situation. In the current scenario, the terror threats have affected both, external as well as internal security situations, globally. In this context, both types of security forces (soldiers as well as police) are required to be 'prepared' to counter/ handle these threats (terror attacks) effectively.

It is well known that most countries across the globe have developed their own Special Forces (SF), to handle terror attacks. Whenever a terror attack occurs, since SF do take/ need time to reach the scene of attack to take control/ nullify the damage, security personnel deployed as first line of defence, are inevitably the first to bear the brunt of such attacks. In this

context, weapon firing skills of these security personnel (both, defence & police), especially on moving targets, plays a significant role in their effectiveness to counter/ handle such attacks.

Weapon firing training is conventionally imparted on open firing ranges. With advancement in technology, over the years, computer-based simulation technology has significantly changed the training methods of weapon training. Moving target training (MTT) in particular, is imparted in two distinct methods – Physical & by Simulation. Both methods are cost-centric and hence are utilized only by financially strong countries. Owing to affordability issues, most of the under developed and developing countries have largely limited the training of their security personnel, to static targets only. Whereas, proficiency in moving target firing has been identified as a significant factor to counter/ resist terror attacks more effectively. The same has been reiterated through the feedback obtained from preliminary survey of weapon training institutes. Thus, a distinct gap seems to exist between the desired level of preparedness of front-line foot soldiers vis-à-vis their actual preparedness to counter such terror attacks. Hence, the need for a cost effective method to impart moving target training to all security personnel deployed on duties of first line of defence, so as to enhance their ‘preparedness’ to counter terror attacks more effectively.

As a part of this research work, initially, various ideas are generated for proposed MTT physically, through existing infrastructure. After cross-evaluation of relative merits and demerits, ‘traction-method’ has been identified as the most suitable method. The training syllabus was deduced based on analysis of movements of attackers in various attacks of the past. Accordingly, MTT has been planned to be imparted on four different types of motions – Horizontal motion, Slant Motion, Flash Appearance & dis-appearance of target and Random motion of target. Designs (2D-drawings) have been evolved for the proposed model to impart training for these four types of motions. A working model has been fabricated consisting of a chassis and four independent modules. Each module is capable to generate a particular type of motion. Significant aspects taken into consideration during fabrication of the working model are, compliance to all safety norms of firing range, use of ricochet proof materials for fabrication, incorporation of features such as ruggedness, user-friendliness, ease of operability & maintainability, cost-effective mechanisms & spares, etc. SOPs have also been formulated for operations, maintenance, and storage of the working model. The mechanisms used to generate various types of target motions are indigenously and innovatively developed.

The training schedule for proposed MTT is evolved based on the existing norms used for static target training. A total of 10 sessions of training are planned per trainee, where each session represents 4 spells and in turn each spell is equivalent to 5 shots fired as the target moves from one end to the other. In respect of skill assessment, ‘Accuracy’ and ‘Grouping’ have been identified as two important parameters, based on which every firer is graded for his performance. Conventionally, firing skills on static targets are broadly classified into three categories – Good, Above Average and Below Average. A thorough analysis of existing criteria for skill gradation revealed certain practical constraints. As a proposed remedy to existing constraints, a revised skill gradation has been formulated consisting of 5 categories, in place of conventional 3 categories. It is pertinent to note that, the conventional gradation system is time tested and also is equally suitable for skill gradation on moving targets. However, the distinct advantage of the new system is that it helps in distinguishing firers, purely based on their grouping skill, which isn’t feasible with the existing system.

A comprehensive plan has been worked out to conduct field trials, in order to validate the effectiveness of proposed MTT method through the newly conceived traction-method. Volunteer participants have been selected through Stratified Random Technique, representing proportionate sample of various population groups. Initially, before commencement of training, performance of participants (skill grade) has been measured on moving targets. Subsequently, they have been imparted with a total of 10 sessions of training progressively. At the end of training, their performance was once again measured. The difference in their skill grade, before and after completion of training clearly shows significant improvement, attributable to methodical training on MTT. Thus, the proposed MTT model can be said to be successful to impart and improve moving target firing skills by physical means, using conventional infrastructure – open firing ranges. In total, significant observations of the field trials are as appended below:

- (i) Field trials have proven that methodical training on moving targets as proposed has a significant influence in improving the skill of firers on moving targets.
- (ii) Previous skill grade of firers on static targets and degree of difficulty to predict target motion are two major factors that influence the skill grade on moving target firing
- (iii) The quantum of learning (as measured by skill demonstrated) is proportional to number of training sessions (quantum of training) imparted. However, depending on conditions, and beyond a point, the amount of training has no direct/ proportionate effect on quantum of improvement. The major factors influencing these conditions are previous skill grade of firer and degree of difficulty of target movement.
- (iv) The conceived method to generate four different target motions physically on a moving chassis, with the help of four independent modules has proven to be successful.
- (v) Field trails also established validity of certain design features incorporated such as compliance to safety norms, ease of operability, ruggedness of construction, user-friendliness, easy to assemble & dis-assemble, etc.
- (vi) Through the field trials, various SOPs developed for conduct of safe operations, maintenance, and storage (cum transportation) of MTT modules have also been verified to be practical, user-friendly and effective.

As a scope for futuristic studies, further experiments may be carried out to study the effect of certain factors listed below, on the rate of learning:

- (a) Effect of dim light or dark conditions or harsh weather conditions.
- (b) Effect of physical exhaustion (prior to firing) on performance of participants.
- (c) Effect on performance of participants in the presence of simulated cross-fire, where the firer (participant) is required to duck / save himself while he continues to fire at moving targets – a more realistic version of battle-like conditions.

In total, the research work established that moving target firing skills can be imparted (and improvised) in a cost-effective manner, using conventional infrastructure – open firing ranges. This innovative solution has the potential to be useful for all those security personnel (soldiers as well as police), who do not have access / exposure to MTT, by virtue of affordability constraints.

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**Request for Feedback through Questionnaire**

I, KCP Paraasaram, a serving combatant of Indian Air Force (IAF) for the past twenty years, presently posted to Air Force Station Guwahati, Borjhar, am pursuing part-time PhD at IIT Guwahati. As part of my research work, I have undertaken to study the scope for improvisation of Weapon Firing Training to soldiers in the existing Firing ranges. As a part of study, it is my endeavour to gather data from similar fighting forces such as your esteemed organisation, with respect to weapon firing practices currently in practice at your work place(s).

It is requested to spare some of your valuable time to answer the following questionnaire (15 questions) to enable me widen my insight on the subject. For the purpose of convenience, all questions are in the form of multiple choice, from which most suitable option(s) may be chosen. Please feel free to contact me / clarify any doubts regards this study undertaken by me. My contact number is 9444113163. Mail id : kcpiitg@gmail.com

The questionnaire is carefully worded so as to ensure ZERO need to disclose any kind of 'Sensitive Data'. ALL QUESTIONS ARE GENERIC IN NATURE AND DON NOT CALL FOR ANY SPECIFIC / CONFIDENTIAL DATA. This is purely a voluntary contribution /participation from your behalf, based on my request. You are free to ignore / overlook my plea.

Thanking you in anticipation for your cooperation and for sparing your valuable time as well as your experience / ideas.

Regards

**General Details:**

1. Name of the Organisation:
2. Name of the Respondent:
3. \* Contact No. mail id :
4. Total Service Length (Experience):
5. Present Appointment: Since (Date):
6. Previous Experience in Soldier Training Activities: (Yrs)

Note: \* Optional

**DRAFT QUESTIONNAIRE**

1. Is a Weapon Firing Range (open) available in the Unit Premises?  
(a) Yes (b) No
2. What is the Firing Range Size in which Weapon Firing is Practised?  
(a) 25 Yards (b) 50 Yards (c) 100 Yards (d) Open  
Range
3. What is the frequency of Weapon Firing Practice, on an average? Once in a ...  
(a) Month (b) Two Months (c) Quarter (d) Six  
Months

4. What weapons are used for firing Practice?  
(a) Rifles/ SLRs (b) Pistols (c) Machine Guns (d) Combination
5. What are the kind of Targets Used?  
(a) Static (b) Dynamic (Moving) (c) Both (d) Simulation Training
6. Is Simulation Training (Virtual), available? YES / NO  
In case YES, Details of the Product / Equipment Manufacturer?
7. In case of simulation training (Virtual) on weapon firing practice, is the existing setup fully satisfactory? YES / NO ;  
In case NO, what limitations does the present set up pose?  
(a) Does not cater for flexibility of options; Embedded with primitive software  
(b) Unserviceable; Maintainability Issues  
(c) Troops do not get the 'REAL' Feel  
(d) High Cost of Initial Set up; Serviceability issues  
(e) NO feasibility to upgrade the software  
(f) Combination of above reasons { Pl specify (a), (b), (c) etc }  
(g) Any other Reason { Pl explain in own words }

8. Is Dynamic (Moving) Target training available? YES / NO  
If YES, does the present setup meet all training requirements?  
Meets.....Requirements.  
(a) Most (b) Some (c) only Basic (d) Not Sure
9. Do you feel / believe that quality of training enhances if troops are trained on firing at moving targets, vis-à-vis being trained ONLY on Static Targets?  
(a) For Sure (b) Must be (c) No Difference (d) Difficult to Say
10. Given an opportunity to get trained on Dynamic (Moving) Targets, please indicate the preferred directions of the movement of the target?  
(a) Horizontal (b) Vertical (c) Flash (d) Random  
(e) Moving towards / Away from Firer  
(f) Combinations of the above { Pl Specify...(a), (b), (c) etc }  
(g) Any Other movement { Pl explain in own words }
11. In your experience, have you ever seen any formal training set up for practice firing of moving targets?  
(a) In many places (b) Specific / Chosen places (c) Very Few (d) Seldom

12. Is it possible to replicate the training setup (Q.No. 11) in your present location?
- (a) Not at all      (b) Highly Difficult; Too many Constraints  
(c) Cost & Infrastructure Constraints      (d) Maintainability issues  
(e) Combination of above { Pl Specify (a), (b), (c) etc }  
(f) Any other reasons { Pl explain in own words }
13. In case a training infrastructure needs to be set up for facilitating firing practice on moving targets, in your opinion, what shall be major constraints
- (a) Infrastructure      (b) Cost / Budget Allocation      (c) Maintainability  
(d) Time of execution      (e) Clearance from Higher Formation  
(f) Combination of above { Pl Specify (a), (b), (c) etc }  
(g) Any other reasons ? { Pl explain in own words }
14. In case of availability of a training set up for practice firing on moving targets in near vicinity (Air Force Station Guwahati premises), would you prefer to send your troops to get trained ?
- (a) For sure      (b) Constrained to Send      (c) Consider Not necessary
15. In your opinion, in the context of lethal attacks by terrorists and rouge groups on Security Forces personnel, how relevant is the importance of firing practice to the troops / soldiers, on moving targets
- (a) Absolutely Essential      (b) Useful to a Large extent  
(c) Makes a little Difference      (d) Not much of difference  
(e) Any other opinion { Pl Specify in own words }

**MOVING TARGET TRAINING SYSTEM**

**SOP For MAINTENANCE**

**Activities to be undertaken, Pre & Post use of the system**

1. Moving Target Training (MTT) System consists of a chassis and four independent modules, to impart training on four different types of target movements. These modules are mountable on the chassis, one at a time, to generate a particular type of motion. Chassis along with the modules moves on a custom designed track. The traction force for the MTT system is obtained from an electric motor, transferred to chassis through suitable drive transfer mechanism. V-belts of requisite sizes are used for motion transfer for various drive mechanisms, employed in different modules as per design.

2. To ensure smooth operations, certain basic checks/ maintenance activities are required to be carried out on MTT system. These checks are broadly divided into two: pre-checks & post-checks. Pre-checks, to be carried out before start of MTT operation aid in trouble-free operation. Post-checks, to be carried out after completion of MTT use, aid to keep the system in ready-to-use condition for subsequent utilisation, as and when necessary.

3. **List of Pre-checks**

The first and foremost pre-checks are to be carried out on are on Track, Chassis and Electric motors (Qty-02) to ensure that they are in fully serviceable condition. For this, the following needs to be ensured:

- (a) Clean the dust, sand and other foreign objects if any, on the track with a cloth. This is to ensure smooth rotation of chassis wheels on the track while in motion.
- (b) Check and ensure the tightness of metal rope, used to pull-push the chassis. If required, tighten as necessary with the turn buckle.
- (c) Check for tightness of wheel mountings, hubs & bearings on the chassis. Tighten if found loose.
- (d) Clean the driver & driven pulleys, free of any dust or sand. Smear grease if found dry.

- (e) Check for any cuts or twists on V-belts used for transferring the drive, for motors as well as for chassis. Ensure there are Nil damages. Replace if necessary. Check & tighten V-belts as necessary.
- (f) Remove dust protection covers on the motors as well as other elect accessories such as limit switches. Check & ensure that there are no naked wires or loose electrical connections. Repair as necessary.
- (g) Check for physical alignment of various driver & driven pulleys to ensure efficient drive-power transfer.
- (h) Run the motors, off-load for atleast for half a minute each and ensure smooth operation, prior to running the motors on full load of chassis.
- (j) Set the chassis on motion, powered by the motors. Check for free motion of chassis on track and ensure there are no abnormal sounds due to loosened mountings or otherwise. If required, re-fill grease into the wheel hubs through grease nipples. Wipe clean.
- (k) After performing all the above activities, halt the chassis at the LHS end of track, as viewed from the firer's point. The chassis system is now in ready to use condition.
- (l) Depending on type of motion on which MTT is planned to be imparted, assemble and fix that particular module on to the chassis. The SOP for assembly & dis-assembly for each module is given separately.

4. **List of Post-checks.**

The following are the list of post-checks that need to be carried out after completion of training activity/ session. These checks are necessary to keep the MTT system in ready-to-use condition for next subsequent use.

- (a) Loosen all V-belts, free of tension, and stow them appropriately.
- (b) Check for any loose or dislodged rivets and/ or broken joints of any of the support frames of track. If found, repair as necessary.
- (c) Check for any frayed ends or cuts in the entire length of metal rope used to pull-push chassis. Repair if found/ necessary. Smear grease to all joints, pulleys and to turnbuckle.
- (d) Clean external surfaces and apply (smear) grease to all bearings, wheel hubs, pulleys, and all other moving parts.
- (e) Cover motors and other elect accessories with dust protection covers.

## **MOVING TARGET TRAINING SYSTEM**

### **SOP For Safe Storage & Transportation**

1. Moving Target Training (MTT) System consists of a chassis and four independent modules, to impart training on four different types of target movements. These modules are mountable on the chassis, one at a time, to generate a particular type of motion. Chassis along with the modules moves on a custom designed track. All four training modules are made of hollow aluminium (Al) structures for three reasons/ advantages. First, to avoid the possibility of ricochet in case of accidental bullet hit. Second, to minimise the weight of the system. Third, aluminium is corrosion resistant, hence ensures longer life. Since the modules are made of hollow Al structures, there is a need to handle them safely during storage, transportation, assembly & dis-assembly, so that the equipment/ items do not get damaged due to mis-handling or wrong handling. The following precautions are to be followed at all times, for safe handling of equipment:

- (a) When in dismantled condition, hold the frames/ structure members in ear-marked places and keep them to rest/ store in 'specific orientation' ONLY. Rough handling of hollow aluminium members (fragile) during storage or transportation is likely to bend or twist certain parts of the modules that might lead to unserviceability. Specific care needs to be exercised while handling fragile members such as hollow aluminium pipes, target frames & attachments, etc.
- (b) All members, in dismantled condition, are to be stored or transported in 'as-it-is' condition, i.e., separated physically from each other. Stowing of dismantled structures one over the other is a strict NO, since it is likely to result in damage to individual (fragile) members.
- (c) Different sizes of V-belts are used in different modules as per requirement. When not in use, all V-belts are rolled & stowed neatly in a housing provided on the chassis for that purpose. It is to be ensured at all times, that the V-belts are not unduly (excessively) twisted while in stowed condition. Excessive twisting or compressing of belts during stowing may result in damage to belts and likely to result in deteriorated performance. Hence, check & ensure proper stowing always.
- (d) The system is designed such that, various assemblies are interlocked with each other with the help of quick-release mechanisms and with the help of nuts & bolts, which just need to be tightened a little more than hand-tightening. No special tools are required, either during assembly or dis-assembly, except for common tools such as common screw driver & basic cutting plier. This feature

of 'simple locking mechanisms' has been specifically incorporated, to enhance user-friendliness. The resultant risk associated is that in case, by mistake, if any of the nut/ bolt is not tightened adequately, such nuts or bolts may fall off due to vibrations generated by chassis motion. Hence, after completion of training on a particular module, when it is being dismantled, all nuts & bolts are to be accounted for, to prevent any 'losses' due to missing/ fallen bolts. In case missing, replace as necessary.

**Note:** The design of locking mechanism per say is satisfactory / 'in-tact'. That is, once tightened adequately, it shall withstand vibrations and do not get loosened by chassis motion. However, the above precaution is to avoid losses due to non-tightening of bolts or nuts by mistake (overlook). This precaution has been incorporated subsequently, based on field experiences.

- (e) In the same context as above, if these nuts & bolts are not adequately engaged/ tightened with each other when in dismantled condition, some of these nuts or bolts, may fall-off during storage or transportation too. Hence, at the beginning of every session, it needs to be checked and ensured that there are no missing nuts or bolts that may have fallen-off during storage or transportation. In case missing, replace them.

## **MOVING TARGET TRAINING SYSTEM**

### **SOP for Assembly & Dis-assembly and Operation of all Modules**

**Note:** This SOP has four sub-parts. Each part consists of a separate SOP for each module as mentioned under:

SOP for Mod-1: Pg 1-2

SOP for Mod-2: Pg 3-4

SOP for Mod-3: Pg 5-6

SOP for Mod-4: Pg 7-9

### **SOP for Assembly & Dis-assembly and Operation of Mod 1**

1. Moving Target Training (MTT) System consists of a chassis and four independent modules, to impart training on four different types of target movements. These modules are mountable on the chassis, one at a time, to generate a particular type of motion. Chassis along with the modules moves on a custom designed track. The traction force for the MTT system is obtained from an electric motor, transferred to chassis through suitable drive transfer mechanism. V-belts of requisite sizes are used for motion transfer for various drive mechanisms, employed in different modules as per design.

#### **Module 1 : Horizontal Motion of Target**

2. The superstructure for Mod 1 consists of two vertical beams and one horizontal beam. The two vertical beams serve as base support for the horizontal beam. The horizontal beam has provision to hold three targets. The sequence of steps to be carried out to operationalise Module 1 are as appended below:

- (a) Insert both the vertical support beams of Mod-1, one each, on either ends of chassis in the groves provided. These shall serve as vertical supports to the horizontal beam.
- (b) The horizontal beam is placed on vertical supports such that it is parallel to the track.
- (c) Horizontal beam has provision to support three target frames. Insert three target frames in to the slots available on the horizontal beam. Fix target papers onto the frames.

- (d) Check & ensure that extra drive belts (V-belts) on the chassis, provided for other modules (mods 2, 3 & 4), are stowed properly in the housing provided on the chassis for that purpose, so that they do not cause any hindrance to the chassis while in motion. Also ensure that the belts are not excessively twisted while in stowed condition.
- (e) A cam is provided in-built, on the driving shaft of the chassis. A 'cam-arm' is also in-built on the superstructure of chassis, which is utilised for Mod 3 operation. Check & ensure that the 'cam-arm' (useful for module-3) is secured in 'retracted' position with a hand-tightened nut-bolt, such that it is clear (not touching) of the cam provided on driving shaft.
- (f) Before the start of firing session, check and ensure there are no loose objects in the firing area and that nothing is visible except for the targets from the firers' view point. Operate the Mod 1 system for desired period/ number of times with the help of electrical switch provided.
- (g) After completion of training session, first, remove the target frames from the horizontal beam. Subsequently remove the horizontal and vertical members from the chassis, so that the chassis is in ready-to -use condition for fitment of next module.
- (h) Once removed, check the individual members for any physical damage either due to accidental hit by any of the fired bullets or for any other reason. Repair if necessary. Store all dis-assembled members of Mod 1 in assigned storage area as per SOP.

## **MOVING TARGET TRAINING SYSTEM**

### **SOP for Assembly & Dis-assembly and Operation of Mod 2**

1. Moving Target Training (MTT) System consists of a chassis and four independent modules, to impart training on four different types of target movements. These modules are mountable on the chassis, one at a time, to generate a particular type of motion. Chassis along with the modules moves on a custom designed track. The traction force for the MTT system is obtained from an electric motor, transferred to chassis through suitable drive transfer mechanism. V-belts of requisite sizes are used for motion transfer for various drive mechanisms, employed in different modules as per design.

#### **Module 2: Slant Motion of Target**

2. The superstructure for Mod 2 consists of a  $\Pi$ - shaped structure (inverted U shape), which houses the drive transfer mechanism. This mechanism, consisting of driver & driven pulleys, converts horizontal motion of chassis into vertical motion of target. Two targets are attached to the V-belts of the vertical drive mechanism. The 'target-guide' system is also fixed on the super structure. Two roller guides, one for each target prevent the target from swaying while in motion along with chassis. The sequence of steps to be carried out to operationalise Module 2 are as appended below:

- (a) Position the two vertical beams of module-2 along with the driven shaft and two pulleys, into the slots provided on the chassis.
- (b) Engage V-belts of module-2 on both pulleys of the shaft. Engage roller guides on either of the V-belts into the respective 'target-guide' slots provided on the vertical frame. The roller guides are bracketed to the V-belts. The brackets also house a provision to attach target frames.
- (c) Once the roller guides are engaged appropriately, tighten the V-belts by raising the height of  $\Pi$ -structure. Ensure that both vertical beams are raised simultaneously, to create equal and adequate tension in the V-belts. The belts are now ready for drive-transfer.

- (d) Engage module-2 target frames to the brackets riveted on both V-belts. Ensure that the initial position of target frames is at the opposite ends on either belts, i.e. one target frame is on the top end of one belt and the other target frame is on the bottom end of the other belt. Insert target papers into the frames.
- (e) Check & ensure that extra drive belts (V-belts) on the chassis, provided for other modules (mods 1, 3 & 4), are stowed properly in the housing provided on the chassis for that purpose, so that they do not cause any hindrance to the chassis while in motion. Also ensure that the belts are not excessively twisted while in stowed condition.
- (f) Before the start of firing session, check and ensure there are no loose objects in the firing area and that nothing is visible except for the targets from the firers' view point. Operate the Mod 2 system for desired period/ number of times with the help of electrical switch provided.
- (g) After completion of training on module-2, follow the sequence of dis-assembly as mentioned. First, dismantle the target frames. Next, loosen the V-belts by lowering the vertical beams by loosening locknuts with the help of T-handle. Subsequently, disengage the rollers from respective guides. Then, disengage V-belts off the pulleys. Lastly, dismantle the two vertical beams along with driven shaft & pulleys. After dismantling all parts of Mod 2, ensure that the chassis is in ready-to-use condition for fitment of next module.
- (h) Roll/tie-up V-belts and stow them back in the slot / housing provided for the purpose. Ensure that the belts are not excessively twisted in stowed condition.
- (i) Once removed, check the individual members for any physical damage either due to accidental hit by any of the fired bullets or for any other reason. Repair if necessary. Store all dis-assembled members of Mod 2 in assigned storage area as per SOP.

## **MOVING TARGET TRAINING SYSTEM**

### **SOP for Assembly & Dis-assembly and Operation of Mod 3**

1. Moving Target Training (MTT) System consists of a chassis and four independent modules, to impart training on four different types of target movements. These modules are mountable on the chassis, one at a time, to generate a particular type of motion. Chassis along with the modules moves on a custom designed track. The traction force for the MTT system is obtained from an electric motor, transferred to chassis through suitable drive transfer mechanism. V-belts of requisite sizes are used for motion transfer for various drive mechanisms, employed in different modules as per design.

#### **Module 3 : Flash Appearance & Dis-appearance of Target**

2. Module 3 consists of a superstructure with a specially designed mechanism (SDM) which can convert horizontal motion of chassis into flip motion of the target with the help of cam mechanism, spring-loaded sliding shaft and a hinge mechanism. When the chassis moves, the cam provides necessary 'push' force to the spring-loaded sliding shaft. As the shaft reciprocates, it causes the hinge mechanism to flip. Targets are attached to the hinge mechanism and hence flips along with the hinge. This results in the target to appear & disappear like a flash. The sequence of steps to be carried out to operationalise Module 3 are as appended below:

- (a) Insert the two vertical support beams of module-3, one each, on either ends of chassis in the groves provided. These shall serve as support beams for the horizontal beam of module-3, which has a provision to hold two targets. Pl note that, the vertical and horizontal beams of module-3 are the same as that used for module 1.
- (b) The horizontal beam is placed on vertical supports such that it is parallel to the track.
- (c) Fix target papers onto two frames, and insert the two target frames in to the slots provided on the horizontal beam. Ensure that targets face towards LHS of range as viewed from firer's point, i.e., initially the targets are in 'dis-appear' mode. Lock the position of target frames by inserting split pins in the alignment holes.
- (d) Check and ensure that the cam, initially, is in vertical position when the target frames face towards LHS – as viewed from firer's point, i.e. in 'dis-appear' mode.

- (e) Loosen the hand tightened nut & bolt to release the 'cam-arm' of module-3 from its 'retracted' position and extend it maximum towards the cam of driving shaft. Lock the 'cam-arm' in extended position with the same nut & bolt (hand tightened). This ensures that cam is now ready to deliver the necessary 'push' force.
- (f) Check & ensure that extra drive belts (V-belts) on the chassis, provided for other modules (mods 2 & 4), are stowed properly in the housing provided on the chassis for that purpose, so that they do not cause any hindrance to the chassis while in motion. Also ensure that the belts are not excessively twisted while in stowed condition.
- (g) Before the start of firing session, check and ensure there are no other loose objects in the firing area and that nothing is visible except for the targets from the firers' view point. Operate the Mod 3 system for desired period/ number of times with the help of electrical switch provided.
- (h) After completion of training operation, first, ensure that 'cam-arm' is retracted back to its extreme position, away from cam, and locked (hand-tightened) in that position, i.e., 'retracted' position, with the help of nut-bolt provided. Remove the two target frames. Lastly, remove the horizontal and vertical members from the chassis, so that the chassis is in ready-to -use condition for fitment of next module.
- (j) Once removed, check the individual members for any physical damage either due to accidental hit by any of the fired bullets or for any other reason. Repair if necessary. Store all dis-assembled members of Mod 3 in assigned storage area as per SOP.

## **MOVING TARGET TRAINING SYSTEM**

### **SOP for Assembly & Dis-assembly and Operation of Mod 4**

1. Moving Target Training (MTT) System consists of a chassis and four independent modules, to impart training on four different types of target movements. These modules are mountable on the chassis, one at a time, to generate a particular type of motion. Chassis along with the modules moves on a custom designed track. The traction force for the MTT system is obtained from an electric motor, transferred to chassis through suitable drive transfer mechanism. V-belts of requisite sizes are used for motion transfer for various drive mechanisms, employed in different modules as per design.

#### **Module 4 : Random Oscillatory Motion Target**

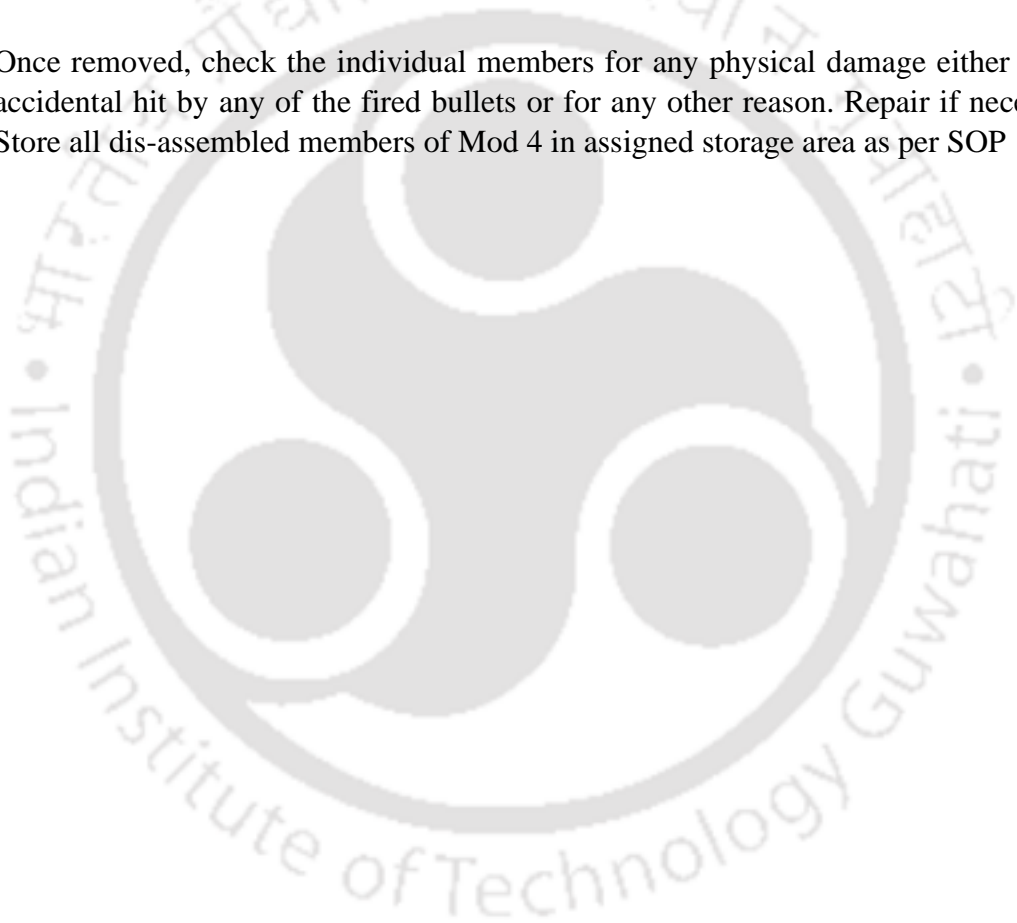
2. In Mod 4, a specially designed mechanism (SDM) consisting of cams & spring-loaded shafts is utilised to induce oscillations into the target while the chassis moves horizontally. The simultaneous motion of chassis and targets together, causes the targets to oscillate with unpredictable amplitude and frequency, thus resulting in random oscillatory motion.

3. SDM consists of two vertical members to which spring-loaded shafts are attached. Targets are attached the outer ends of this shaft. A driving shaft (upper) is housed between the two vertical members and connecting them. Two cams are operated by the upper driving shaft which provides the pushing force to the spring-loaded shafts. As the shafts reciprocate, it causes/ induces random oscillations to the target. The sequence of steps to be carried out to operationalise Module 4 are as appended below:

- (a) Position vertical frames (Qty-02) of module-4 into the slots provided on the chassis.
- (b) The target frames of module-4 are mounted on sliding rods attached to the vertical frames. Pushback the sliding rods away from each other and arrest their movement in that 'retracted' position using sliding/locking pins provided. Check and ensure that the cam-plates (rectangular plates) of the sliding rods are vertical as well as parallel to each other.
- (c) Loosen the mounting nuts of hub. Position the driving hub, along with shaft and driving pulleys, on the mounting brackets provided on the two vertical frames. Ensure that the cams provided on the shaft are in vertical position.

- (d) Engage the 'driving' belts on to the shaft. While doing so, ensure that they are engaged correctly in the corresponding groves in the 'driving' shaft located beneath.
- (e) Tighten the hubs with spanner. This now serves as the 'driven' shaft and 'driven' pulleys. Engage the V-belts on to the pulleys.
- (f) Release the locking pins and set free the sliding rods which were earlier arrested in retracted position. Engage the locking pins in the respective slots provided. Check and ensure that the cams of the shaft engage the respective cam-plates of sliding rods centrally.
- (g) Engage V-belts on to the pulleys. Raise the two vertical frames simultaneously using lock-nut mechanism provided. This is to create equal and adequate tension in the V-belts to ensure positive drive.
- (h) Engage target frames in the slots provided on mounting brackets of the sliding rods. Hand-tighten them with nut-bolt provided. Either two or four targets can be engaged simultaneously as per requirement. Check and ensure free oscillatory motion of the target frames. Insert target papers in the frames.
- (j) Check & ensure that there are no screws/ bolts which are left loose or not secured.
- (k) Check & ensure that extra drive belts (V-belts) on the chassis, provided for other modules (mods 1, 2 & 3), are stowed properly in the housing provided on the chassis for that purpose, so that they do not cause any hindrance to the chassis while in motion. Also ensure that the belts are not excessively twisted while in stowed condition.
- (l) Before the start of firing session, check and ensure there are no other loose objects in the firing area and that nothing is visible except for the targets from the firers' view point. Operate the Mod 4 system for desired period/ number of times with the help of electrical switch provided.
- (m) After completion of training on module-4, first, lower the vertical beams by loosening locknuts. Then, 'retract' the sliding rods and arrest them in that position using respective lock-pins.
- (n) Loosen mounting bolts of hub and disengage V-belts. Remove the driven shaft along with pulleys.

- (o) Remove the lock-pins and set free the sliding rods to their original (normal) position. Secure the lock-pins in the respective slots provided.
- (p) Lastly, dismount the vertical beams along with target frames. Target frames may be dismounted from the vertical beams subsequently.
- (q) Roll/tie-up V-belts and stow them back in the slot / housing provided for the purpose. Ensure that the belts are not twisted in stowed condition. Lastly, ensure that the chassis is in ready-to-use condition for fitment of next module.
- (r) Once removed, check the individual members for any physical damage either due to accidental hit by any of the fired bullets or for any other reason. Repair if necessary. Store all dis-assembled members of Mod 4 in assigned storage area as per SOP



## List of Publications

1. Paraasaram, K. C. P., Sharma, N., & Salve, U. R. (2019). **Multi-utility Fantasy Bed: Experimental Design**. Proceedings of ICoRD 2019 Vol1 in book Research into Design for a connected world (pp.871-886). ISBN 978-981-13-5974-3 (e book) [https://doi.org/10.1007/978-981-13-5974-3\\_75](https://doi.org/10.1007/978-981-13-5974-3_75)
2. Paraasaram, K. C. P. & Salve, U. R. (2021). **Proposed improvisation in gun shooting skills, especially on moving targets to enhance efficacy of shooting training vis-à-vis modern day's security preparedness**. *Proceedings of HWWE-21 Vol-391, Ergonomics for Design & Innovation* (pp. 472-481) ISBN 978-3-030-94277-9 (e book) <https://doi.org/10.1007/978-3-030-94277-9>
3. Paraasaram, K. C. P. & Salve, U. R. (2023). **Spotting Potential raw sporting talent in India at grassroot level for gun-shooting sport: Proposed Methodology**. Proceedings of ICoRD 2023, Design in the era of Industry 4.0, Vol-2 (pp.621-634) Smart Innovation, Systems and Technologies, Vol-342. ISBN 978-981-99-0264-4 (e book) [https://doi.org/10.1007/978-981-99-0264-4\\_52](https://doi.org/10.1007/978-981-99-0264-4_52)

## Conference Papers Submitted

1. Paraasaram, K. C. P. & Salve, U. R. (2020). **Weapon Firing Training for Security Forces: Study Review**. In HWWE-2020 @ Theme College of Engineering Boisar, Mumbai

