Research Report 2009

Realism and Effectiveness of Robotic Moving Targets

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14. ABSTRACT
For the vast majority of U.S. Army Soldiers, the first opportunity to engage a realistic moving target with small arms is in combat. Even Infantry Soldiers and special-skill Soldiers (e.g., snipers) have very limited opportunities to train realistic moving-target engagements. Without the opportunity to practice engaging realistic moving targets, the Soldier is not able to develop the correct perceptual and motor tuning to adequately engage live moving targets. One solution for the lack of moving target training capabilities is the use of robotic human-type targets (RHTTs). RHTTs can present a realistic three-dimensional human-sized target that can freely move with semi-autonomous control. The U.S. Army Research Institute for the Behavioral and Social Sciences was asked to assist in the assessment of the effectiveness and perceptions of this capability. Perceptions of realism, shooting performance metrics, and training capabilities inventories were collected from Soldiers training with one type of RHTT to determine effectiveness and realism. Overall, the evidence suggests that RHTTs can help improve performance on moving target tasks and RHTTs were perceived positively by Soldiers who trained with them.

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REALISM AND EFFECTIVENESS OF ROBOTIC MOVING TARGETS

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army Infantry School Commandant requested assistance from the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) at Fort Benning, Georgia to assess the training effectiveness and Soldier perceptions of robotic moving target technology. The technology assessed under the current effort was Robotic Human Type-Targets (RHTTs), autonomous robots that can be used for moving target live fire training.

Procedure:

Performance and survey data were collected during multiple training exercises from Soldiers who engaged the RHTTs. Different groups of Soldiers engaged in each training exercise. Performance data were collected for each training exercise. After completing the training scenarios, participants completed a background questionnaire and user survey.

Findings:

Experienced Snipers and Soldiers significantly increased their proportion of moving target hits after training with RHTTs. Likewise, United States Army Sniper Course (USASC) students who initially trained moving-target engagements with RHTTs significantly increased their proportions of moving targets hits. Soldiers' perceptions of the RHTTs training indicated that RHTTs had training utility, helped improve performance, and provided training realism. Generally, the movement of the RHTTs was praised along with the realism of the training. Soldiers suggested multiple ways to improve the RHTTs including specific feedback on hit location and smoother movement over rough terrain.

Utilization and Dissemination of Findings:

The research findings suggest that RHTTs could have a positive impact on performance and that Soldiers tend to find the training engaging. The findings were included in an information paper (November, 2015) for the Maneuver Center of Excellence's Directorate of Training and Doctrine. Future research could directly compare the effectiveness of RHTTs with the effectiveness of current moving target training systems.

REALISM AND EFFECTIVENESS OF ROBOTIC MOVING TARGETS

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Introduction

For many U.S. Army Soldiers, the first opportunity to engage a realistic moving target with small arms live ammunition is in combat. Even Infantry Soldiers and special-skill Soldiers (e.g., snipers) have limited opportunities to train realistic moving-target engagements. Dyer (2016) surveyed leaders from 14 Army branches on unit marksmanship training in 2012-2013. Over 90% of Infantry and Field Artillery leaders surveyed identified hitting moving targets as a high priority individual marksmanship skill.

Engaging moving targets is a complex skill. Engaging lateral or oblique moving targets requires the shooter to lead the target, not aim directly at the target. Lead is the distance the aiming point must be placed in front of the target's movement whether using the tracking or trapping engagement technique. Tracking and trapping are two techniques to engage moving targets. Tracking involves moving the rifle with the target and firing (more difficult); trapping (or ambushing) involves establishing an aiming point and firing when the target reaches it (less difficult). More information concerning engagement techniques can be found in TC 3-22.10 *Sniper Operations and Training* (Department of the Army [DA], 2013). Determining the amount of lead requires the shooter to consider the distance to the target, the target's speed and direction of movement (walking, running, lateral or oblique, towards or away from the shooter), time of flight of the bullet (higher muzzle velocity = shorter time of flight [less lead], lower muzzle velocity = greater time of flight [more lead]), and the direction and speed of the wind. The closer the target is to the shooter, the less of a combined impact these factors have, the further the distance from the shooter, the more impact. Becoming proficient at engaging moving targets requires significant practice.

Research has consistently demonstrated that deliberate practice over an extended period is necessary to develop expert performance (Ericsson, Krampe, & Tesch-Römer, 1993). There are many obstacles for Soldiers to engage in the deliberate practice needed to obtain expert performance in moving target marksmanship. One obstacle is the opportunity to train. Crews of ground based direct fire systems – for example, the M1-series Abrams Tank and M2/3-series Bradley Fighting Vehicle – are resourced for and engage moving targets as part of the practice and qualification tables in the integrated weapons training strategy (DA, 2016a). However, moving target training for individual Soldiers is often a small portion of marksmanship training and currently does not include any practice or qualification tables (DA, 2016b), and is subsequently not specifically resourced (DA, 2015). Another obstacle to moving target training and the focus of this paper, is the limitations of the training systems available. The moving target systems currently available to the U.S. Army are limited in terms of realism and effectiveness. Without the opportunity to engage realistic moving targets, Soldiers are not able to develop the correct perceptual and motor tuning needed to adequately engage live moving targets. The overall goal of the current research effort was to determine if new robotic target technologies could provide opportunities to increase moving-target engagement skill.

Current Moving Target Systems

There are three systems currently available to the Army that provide Soldiers the opportunity to engage moving targets during small arms live-fire training: Moving Infantry targets, target sleds, and walking targets. The first two systems use D1 or E1-type targets, while the third system uses primarily E2-Type targets. These targets are standard U.S. Army personnel targets made of green plastic (D1 and E1) or pasterboard (E2) that are 40 inches tall and 20 inches wide.

Moving infantry targets. D1 or E1-type targets are fixed to automatic target lifters mounted on a rail system. Targets move bi-directionally (right and left) or towards or away from the firer at varying speeds. Targets can move in an oblique direction if the rail system is laid-in in the appropriate direction from the firing point. Target scenarios are programmed into a computer that controls exposure, movement, and automatically resets the targets after each engagement (DA, 2016c).

Personnel field-expedient targets. TC 7-9, Infantry Live Fire Training (DA, 2009) describes two approaches to moving targets. For the moving personnel falling target approach, E-type targets are attached to large balloons hanging from a pulley on an angled cable. Target movement is provided by human or mechanical power and targets have to be manually reset after each engagement. An alternative approach is to use a personnel target sled by attaching E-type targets to a sled which is moved by human or mechanical power. For both types of targets speed varies based on human or mechanical strength.

Walking targets. Walking targets are used in a Known Distance (KD) range where E-type targets are attached to wooden pickets and moved laterally in the target pits by Soldiers. Speed and distance vary based on movement by the Soldiers. When a walking target is hit, the location of the hit is marked so the Soldiers can see the location of their shots.

The current moving target systems are limited in terms of realism and effectiveness. Movement for two systems is limited to bi-directional left to right movement and speed is governed by Soldier or mechanical strength. Moving Infantry targets do provided additional capabilities but the targets are presented at a fixed distance from the firing position and changing target distance requires either Soldiers to move to alternate firing positions or presenting targets at varying range bands. Current targets present a 2-dimensional view (i.e., frontal or standard side view) and most cannot be used to simulate a target that is oblique or that presents varied exposures.

Robotic Human Type Targets

Robotic Human Type Targets (RHTTs) address many of the limitations of current moving target training systems. The RHTTs used for this research were Marathon® Smart Targets (www.marathon-targets.com, see Figure 1). The targets present a three-dimensional human torso on an all-wheel drive steel-plated mobile base. The torso is made of self-healing plastic that can receive 1000+ rounds before being replaced. Hits are recorded by acoustic baffles in the torso, and there are separate baffles for “vital” areas (i.e., head, heart, and lungs)

and peripheral areas. "Kills" can be programed to require some combination of multiple hits or vital hits. The torso lowers after a hit to provide feedback. The torso can be dressed or equipped to represent enemy personnel or friendly personnel without impeding hit detection or feedback.

The Smart Target mobile base is driven on four foam-filled tires, which can withstand multiple shots. The armor plates can withstand 5.56 mm, 7.62 mm, and .338 cal. ammunition. The mobile base uses a combination of laser sensing, global-positioning satellite, and wireless signal to navigate the terrain. The target can be preprogrammed to follow a given scenario or be manually controlled. The targets can communicate with other nearby targets, which means they can move independently, as a group, or can "react" to actions on other targets (e.g., seek cover once one target in a group is hit). The mobile base can also play sound to add realism to the training scenario, although sound was not used in the current research. Table 1 summarizes the capabilities of each type of existing target system and the capabilities of the RHTTs.

Figure 1. Robotic Human Type Target

Importance of Realism

Moving target training presents an interesting case for training realism/fidelity. It was long assumed that more fidelity meant better training outcomes (Salas, Bowers, & Rhodenizer, 1998). Researchers have more recently determined that more fidelity does not always result in increased performance. Though there has been some consideration of the importance of fidelity of the simulated weapon in marksmanship simulation training (e.g., White, Carson, & Wilbourn, 1991), there has been less concern about the importance of target fidelity in live fire marksmanship training. What is being simulated in live fire training is the target. Often, the target has near zero fidelity compared to the actual human targets. Live fire training in basic training in the Army may use a target grid fore zeroing and E-Type targets, which have the shape of a human silhouette, for firing. Much of marksmanship training is conducted on stationary targets. These targets do not reflect the type of targets Soldiers are expected to engage in combat situations. It is arguable that the fidelity of target movement is more important than the fidelity of a stationary target due to the complexity of engaging moving targets. Therefore, the fidelity or realism of the "moving" target is considered in the current research.

Current moving target training systems lack realism on a variety of dimensions. Soldiers are expected to engage moving human targets in combat and the current training systems cannot replicate human behavior. Of the current training systems, the moving infantry target system appears to have the highest degree of realism, but it has several critical limitations. Like the target sleds and the walking targets, the moving infantry targets are limited to bidirectional

movement while a human target could move in any direction. Though the moving infantry targets are capable of variable speeds, the speeds do not replicate the full range of human capabilities. The current systems are also limited in the variety and difficulty of possible scenarios. For example, the current systems cannot support multiple targets, having civilians on the battlefield, or having a target hide behind a barrier.

Table 1
Comparison of Moving Target Training System Capabilities

Current U.S. Army Systems			Demonstrated System
Moving Infantry Targets	Target Sleds	Walking Targets	Robotic Human Type Targets (RHTTs)
• Digital.	• Analog.	• Analog.	• Digital.
• Permanent infrastructure.	• Mobile, requires construction	• Infrastructure dependent, requires construction	• Mobile.
• Computer programmed	• Manually operated	• Manually operated	• Computer programmed
• Limited engagement scenarios.	• Restricted engagement scenarios.	• Restricted engagement scenarios.	• Unlimited engagement scenarios.
• Fixed target distance from firing position.	• Fixed target distance from firing position.	• Fixed target distance from firing positions.	• Variable target distance from firing position
• Bi-directional movement.	• Bi-directional movement.	• Bi-directional movement.	• Omni-directional movement
• Rail restricted movement.	• Terrain, Human, Mechanical restricted movement.	• Infrastructure restricted movement.	• Terrain restricted movement.
• Variable movement speeds.	• Limited movement speed.	• Limited movement speed.	• Variable movement speeds.
• 2-D targets.	• 2-D targets.	• 2-D targets.	• 3-D targets.
• Non-discriminatory hit sensors.	• No hit sensors.	• Human hit sensor.	• Discriminatory hit sensors.
• Immediate feedback if hit.	• Limited feedback if hit.	• Immediate feedback if hit.	• Immediate feedback if hit.
• Target stops, drops, and resets when hit.	• Feedback is based on observation by the firer. Targets do not drop.	• Target is lowered and the "walker" places a 3 or 5-inch white spotting disk at the location of the hit.	• Target stops and the torso dips backwards, resets, and if programmed, continues to move.

General Method

Performance and survey data were collected from Soldiers who engaged the RHTTs. The performance data highlights the difficulty of moving-target engagements and the impact of RHTTs technology on improving moving-target engagement skills. Survey data of Soldier's perceptions of the RHTTs technology provided an assessment of training realism. Methodology and results for performance data are presented first. Next, the cumulative results of the survey data across groups are presented.

Surveys

Soldiers were asked to complete a Background Information Questionnaire (see Appendix A). This questionnaire asked Soldiers to report basic details about their deployment history, such as the number of deployments and the year of their most recent deployment. Soldiers were also asked about how recently they engaged moving targets in training and in combat.

On the RHTTs User Survey (see Appendix B) Soldiers were asked several questions about the realism, utility, and challenge of RHTTs training and asked to respond on a Likert-type scale with four response options ('Strongly Disagree', 'Disagree', 'Agree', and 'Strongly Agree'). Soldiers were also asked to indicate whether RHTTs would be useful in several training environments (such as Individual Tactical Skills, Platoon Battle Drills, and One Station Unit Training [OSUT]/Basic Combat Training [BCT]). Last, Soldiers were asked three open-ended questions on what RHTTs did best, what was liked least about RHTTs, and one improvement to be made to RHTTs.

The Moving Target Skills Questionnaire (Appendix C) asked Soldiers to indicate on a 4-point Likert-type scale their confidence in their ability to execute 15 marksman skills including determining range and hitting a variety of moving and stationary targets. For example, Soldiers responded with one of four response options (Not Confident, Somewhat Confident, Mostly Confident, and Extremely Confident) to statements such as: "Determine range to laterally moving targets," "Hit laterally moving targets." Soldiers completed the Moving Target Skills Questionnaire prior to and after engaging the RHTTs.

Procedure

Data were collected during four training exercises, see Table 2 for a brief description of the participants and measures for each exercise. The general procedure for each exercise was similar. Soldiers were trained in multiple engagement scenarios and performance data were collected. After completing the training, participants completed surveys.

Table 2
Data Collection Events and Surveys

Data Collection Effort	Participants	Performance Measures	Surveys
#1 Capabilities Demonstration	Snipers and Infantry Soldiers	Lateral movers baseline and posttest	•Background Information Questionnaire •Moving Target Skills Questionnaire
#2 USASC Record Fire	Sniper students	Moving-target Record Fire 1 and 2	•Background Information Questionnaire •Moving Target Skills Questionnaire
#3 Sniper Exercises	Individual Snipers	Lateral movers and complex scenarios	•Background Information Questionnaire •RHTTs User Survey
#4 Squad Tactics Exercise	IBOLC Students	Performance data not collected	•Background Information Questionnaire •RHTTs User Survey

Performance Data

Data Collection 1: Capabilities Demonstration

Data were collected from two groups of Soldiers for a capabilities demonstration. Each group participated in three days of training and testing. These Soldiers also completed the Moving Target Skills Questionnaire before and after training and the Background Information Questionnaire after training.

Participants. One group of 11 participants were five sniper/spotter teams with an average of 9 years in service (range: 3-16 years). Three of these teams were instructors at the USASC, one team represented the United States Army Marksmanship Unit, and one team represented an operational unit. Seventy percent of the experienced snipers had deployment experience and these Soldiers had been deployed between 0 and 13 times. The background questionnaire revealed that 73% of the sniper participants had engaged in long-range target shooting within the last month. Though almost half (46%) of participants had not engaged a moving target in training within the last 12 months, 55% indicated they had engaged moving targets in combat.

The second group included one squad (i.e., 9 soldiers) from an Armored Brigade Combat Team (an operational unit) along with two drill sergeants and two Soldiers from Infantry OSUT (an Initial Entry Training unit) with an average of 3.75 years in service (range: <1-13 years). Six participants had been previously deployed with a maximum of four deployments. Only two participants had taken an advanced marksmanship course. The majority (70%) of participants in this group had not trained on moving targets in the past six months. These Soldiers had less experience and training on average than any of the other groups.

Procedure. Soldiers were asked to complete the Moving Target Skills Questionnaire prior to engaging the RHTTs. After completing the questionnaire Soldiers completed a baseline firing test using the RHTTs. For the experienced sniper teams, the baseline test involved engaging 5 left and 5 right lateral moving targets at each of three distances: 200 meters, 400 meters, and 680 meters. For the Infantry Soldiers, the baseline test included engaging 5 left and 5 right lateral movers at 200 meters and 400 meters. The Infantry Soldiers did not engage targets beyond 400 meters as they were using standard M4-series rifles firing 5.56mm ammunition, whereas the snipers were using M110 Semi-automatic Sniper Systems that fire 7.62mm ammunition and have a greater effective range. After the baseline test, the experienced sniper teams engaged the RHTTs in complex scenarios. The Infantry Soldiers received moving target training and had the opportunity to engage the RHTTs in various complex scenarios. Both groups completed a three-day course of fire that ended with a post-test that mirrored their baseline test. After completing the post-test Soldiers were asked to complete the Moving Target Skills Questionnaire again.

Results. The proportion of target hits was compared across baseline and post-test for experienced snipers and the Infantry Soldiers. The proportion of target hits increased (t (22) = 2.79, SE_{diff} = .05, p = .01) from baseline (M = .36, SE_m = .03) to record fire (M = .49, SE_m = .04), which suggested a benefit for training with RHTTs (see Figure 2).

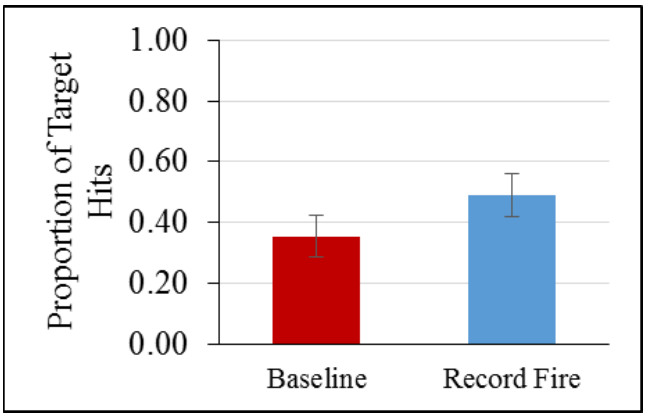

Figure 2. Shooting performance for experienced sniper teams and Infantry soldiers

Discussion

The performance level of both groups (experienced snipers and Infantry Soldiers) increased after engaging the RHTTs. However, because there was no comparison condition in which a current moving target systems was used for training, it is not possible to determine if the increase in shooting performance was due to the RHTTs or to a practice effect. That is, would similar improvements occur by using any of the current Army rifle marksmanship training methods?

Data Collection 2: USASC Record Fire

USASC training provided an opportunity to compare RHTTs training with walking target training. As part of the USASC program of instruction, Soldiers complete moving-target record fire two times, once with the M110 SASS and once with the M2010 Enhanced Sniper Rifle. Students were divided into two groups. Group 1 trained and completed the first record fire with RHTT targets and the second record fire with walking targets. Group 2 trained and completed the first record fire with walking targets and the second record fire with RHTTs. Appendix D contains the record fire requirements for moving targets; target distances are greater for the M2010 (Record Fire 2) because the maximum effective range of the M2010 is greater than the M110.

Participants. Data were collected from 26 active-duty Soldiers who averaged 4.11 years of service (range: 1.5-12.42 years) and 1.03 deployments (range: 0 to 7, 46.43% had never been deployed, 17.86% had been deployed 2 or more times) with 28.57% of Soldiers deployed in 2013 or 2014. Over half of Soldiers (53.57%) had not engaged moving targets in training in the past 12 months and 46.67% of Soldiers with past deployments reported engaging moving targets in combat.

Procedure. Students were divided into two groups. Group 1 used RHTTs for training and record fire with the M110 while the Group 2 used walking targets for the M110. The groups switched targets for training and record fire with the M2010. The first record fire included laterally moving targets at known distances of 300 meters, 400 meters, 500 meters, and 600 meters. The

second record fire included moving targets at known distances of 500 meters, 600 meters, 700 meters, and 800 meters. Shooting performance was compared between RHTT training and walking target training. It should be noted that the order of target type was confounded with order of record fire. That is, students who engaged RHTTs first used the M110 to engage the RHTTs and the M2010 to engage the walking targets. Students who engaged walking targets first engaged walking targets with the M110 and engaged RHTTs with the M2010. This is especially important because the M2010 is considered a more accurate weapon system than the M110. After completing the RHTTs record fire, Soldiers completed the Background Information Questionnaire and the RHTTs User Survey.

Results. Group 1, students who initially trained with RHTTs, increased the proportion of hits on record fire when firing at walking targets, while Group 2, students who initially trained on walking targets, did not increase proportion of hits when firing at RHTTs (F[1, 24] = 37.01, MSE = 6.83, $p < 1$). Figure 3 shows the proportion of hits on each record fire for each group of USASC students. The left-hand set of bars show the proportion of hits for students who initially trained and shot record fire using RHTTs (Group 1), and the right-hand set of bars show the proportion of hits for students who initially trained and shot record fire using walking targets (Group 2). It can be noted that, overall, the proportion of hits on RHTTs (M = .48, SE_m = .02) was lower (t [25] = -3.94, SE_{diff} = .04) than the proportion of hits on walking targets (M = .64, SE_m = .03).

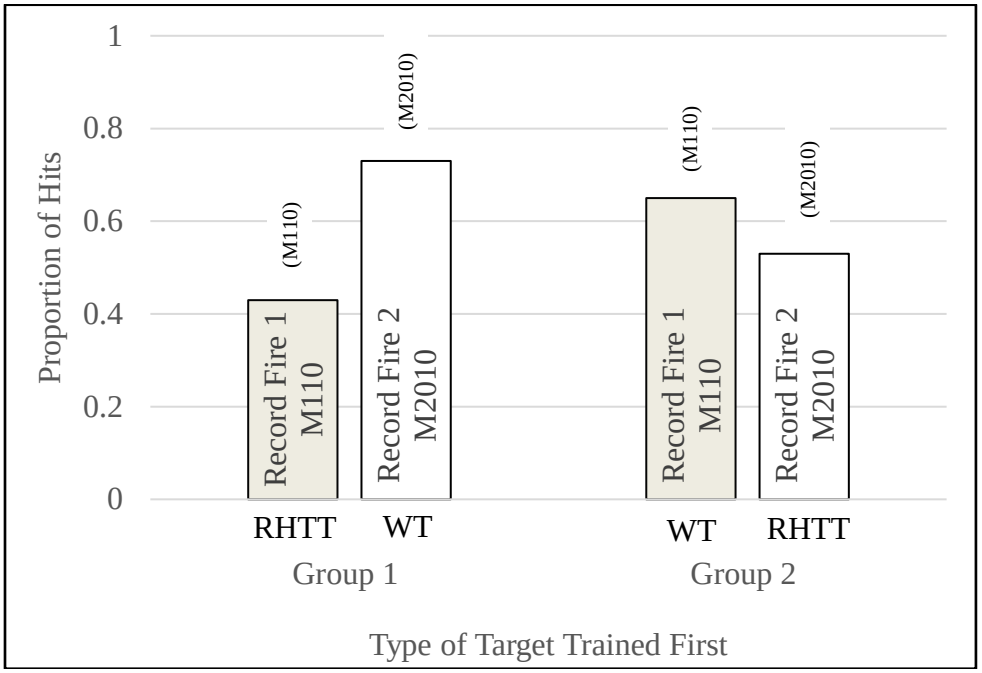

Figure 3. USASC students' moving-target record fires. WT = Walking Target.

Discussion. Students who trained on RHTTs first improved from Record Fire 1 to Record Fire 2. Students who trained on walking targets first performed worse on Record Fire 2 than on Record Fire 1. There are several possible explanations for this finding. First, the gain in hits experienced by students who trained on RHTTs first may be primarily due to the difference in

training effectiveness of the two target systems. That is, the increase in the proportion of hits on walking targets for sniper students who first trained on RHTTs may be due to the training value of RHTTs. Alternatively, it may be the case that the RHTTs are simply more difficult to hit. If this is the case, the improvement seen for Group 1 could be because this group went from the more difficult to less difficult targets while Group 2 went from less difficult to more difficult targets. While walking targets are always going to move in a straight line at a mostly constant speed, RHTTs will slightly vary direction of travel and straight-line speed as they follow terrain and avoid small obstacles. This variation may make the RHTTs more difficult to hit, though it can be argued that this variation (and difficulty) is more realistic. Moving (actual) human targets will vary pace and direction over uneven terrain and around obstacles.

Interpretation of this finding is limited by the potential effect of different weapon systems. The first group engaged RHTTs first with the less accurate weapon (M110), then engaged the walking targets with the more accurate weapon (M2010). With the current data, we cannot disentangle the effect of practice from the effect of weapon type or target type. That is, it is unclear how much of the improvement in the first group is due to 1) practice engaging the RHTTs, 2) engaging a different and likely easier target, and/or 3) using a more accurate weapon system. The second group engaged walking targets with the less accurate weapon (M110) and engaged the RHTTs with the more accurate weapon (M2010). The second group were more accurate engaging RHTTs than the first group, but it is unclear if this is because they had previous practice engaging moving targets, because they were using a more accurate weapon system, or a combination of both.

Data Collection 3: Individual Snipers

Participants. Data were collected from 33 active-duty Snipers who averaged 4.67 years of service (range: 1-14 years) and 1.9 deployments (range: 0-6, 34.3% had never been deployed, 42.9% had been deployed two or more times). Almost half (42.9%) of the Soldiers were last deployed in 2013 or 2014. More than half (51.4%) of the Soldiers indicated that they had not engaged moving targets in training in the last 12 months. Only 11.4% of Soldiers reported engaging moving targets during training more than once or twice in the last 12 months. Close to half (44.4%) of Soldiers who had been deployed reported engaging moving targets in combat. This group included USASC instructors and sniper-qualified Soldiers on assignment at Fort Benning, GA. Generally, individuals in this group shot as individual shooters and not as a sniper team.

Procedure. The individual snipers participated in various capabilities demonstration exercises. The course of fire varied within this group, but all individual snipers shot laterally-moving engagements and complex scenarios with multiple targets and civilians on the battlefield. There was no specific record fire for individual snipers as there was for the other research groups. However, detailed round counts were available for the individual snipers.

Results. Individual snipers fired a total of 1811 rounds at RHTTs across the various events. Individual snipers hit 72% of the targets presented but only hit targets with 21% of rounds fired. In other words, of the 1811 rounds fired at RHTTs, only 388 hits on targets were

recorded. The low shooting efficiency also mirrored the low RHTT shooting performance seen in Figures 2 and 3.

Discussion. The difficulty hitting RHTTs reflects the reported inability to accurately engage moving targets in combat (Dyer, 2016; Ehrhart, 2009). Obviously, moving-target engagements require more skill than static-target engagements. Part of the difficulty engaging moving targets is due to the unpredictability of target location due to natural movement of humans (Scholl & Tremoulet, 2000), and part of the difficulty is due to the fact that no engagement technique is effective at all target distances for all shooters (Schendel & Johnston, 1982). It is important for the Army to develop training programs that reflect the realities of the challenges of engaging moving targets.

Engaging moving targets is a complex skill that requires the shooter to determine how far to lead the target rather than aiming directly at the target. Accurately leading a target requires the shooter to consider the distance to the target, the speed and direction of the target's movement, the characteristics of the ammunition, as well as the potential impact of wind. Current moving target systems, such as walking targets, can be used to allow Soldiers to practice engaging moving targets at different distances, with different types of ammunition or weapons, and with varying wind conditions. However, the current systems are limited in their ability to provide Soldiers with realistic practice regarding the speed and direction of the target's movement. The RHTTs used in the current study were designed to more closely represent the realities of moving (human) target speed and direction. The next section examines Soldier's perceptions of the realism and effectiveness of these targets.

Soldier Perceptions of Realism and Effectiveness

Participants

Soldiers from the capabilities demonstration (Data Collection 1) were asked to complete the Moving Target Skills Questionnaire before and after engaging the RHTTs. Soldiers from the USASC and the individual snipers (Data Collections 2 and 3) were asked to complete the RHTTs User survey after completing their assigned training and testing with the RHTTs. Survey data were also collected from 48 Infantry Basic Officer Leaders Course (IBOLC) Soldiers who engaged RHTTs during a squad-level exercise that emphasized tactics and target engagement. Shot data were not collected for this event because multiple Soldiers were engaging multiple targets simultaneously, and collecting reliable data was not possible. IBOLC Soldiers averaged 3.14 years of service (range: 2 months – 14 years) and just under a quarter (23.91%) of IBOLC Soldiers had been deployed. Of the 11 Soldiers with deployment experience, 72.73% reported engaging moving targets in combat. RHTT User Survey data were collected from IBOLC students and survey data from the groups were combined and the results are presented below.

Results

Moving Target Skills Questionnaire. Experienced snipers and Infantry Soldiers rated their confidence in their ability to hit moving targets before RHTT training and after RHTT training on the Moving Target Skills Questionnaire. While the level of confidence could be informational, the more important metric was whether confidence levels changed after RHTT

training. All of the participants indicated a change in their confidence level between the pre-RHTT training survey and the post-training survey, with 45% of the participants indicating increased confidence and 55% indicating decreased confidence.

RHTTs User Survey. In total, 101 Soldiers completed the RHTTs User Survey. Overall, Soldiers tended to agree or strongly agree that RHTTs could facilitate training a variety of skills, help improve skills, and provide realistic training (see Table 3).

Table 3
Utility – RHTTs User Survey

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
RHTT allowed training that is not now or not easily conducted in marksmanship training.	49%	44%	4%	3%
Training with RHTT improved your individual task performance.	49%	49%	2%	0%
RHTT helped you make sound engagement decisions.	40%	49%	2%	0%
Feedback given by RHTTs was useful for improving your skill.	42%	49%	8%	0%
RHTT provided challenging training.	58%	38%	2%	2%
Training with RHTTs made your unit more prepared to conduct similar live missions.	48%	49%	2%	1%

Soldiers also tended to agree or somewhat agree that RHTTs moved in a realistic manner, that engaging RHTTs was realistic and challenging, and that RHTTs provided sufficiently realistic conditions for moving target training (Table 4).

Table 4
Realism – RHTTs User Survey

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
The RHTTs moved in a realistic manner.	36%	50%	11%	3%
Engaging RHTTs was realistic.	57%	35%	6%	2%
Engaging RHTTs was challenging.	64%	28%	5%	3%
Training with RHTTs provided sufficiently realistic conditions in which to train moving targets.	65%	30%	2%	3%

Soldiers considered RHTTs appropriate for most training environments, see Table 5. Nearly all Soldiers agreed that RHTTs would be useful in live fire environments at the squad

(97%) and platoon (95%) level. RHTTs were also rated as useful for squad (94%) and platoon (93%) battle drills. Over 80% of Soldiers agreed that RHTTs would be useful in the suggested training environments with the exception of Initial Entry training (BCT/OSUT). Feedback regarding the utility of RHTTs in BCT/OSUT was somewhat mixed, with only 68% of Soldiers rating RHTTs as useful in the BCT/OSUT environment.

Table 5
Responses to question "In what training environments would RHTT be useful?"

Training Environment	Yes	No
Squad Live Fire	97%	3%
Platoon Live Fire	95%	5%
Squad Battle Drills	94%	6%
Platoon Battle Drills	93%	7%
Individual Skills	91%	9%
PME Courses	90%	10%
Functional Courses	89%	11%
Squad MOUT	85%	15%
Buddy Team Live Fire	84%	16%
Platoon MOUT	83%	17%
BCT/OSUT	68%	32%

Free Response. The RHTTs User Survey included three open-ended questions. Not all respondents answered each question. On the three questions, 5.9% provided no response to the first question, approximately 24% provided no response to the second question, and approximately 24% provided no response to the third question. However, only 4 respondents (3.96%) did not respond to any of the open-ended questions. On the other hand, many respondents provided multiple responses to the questions. In order to accurately code the content, responses that contained multiple topics were divided into separate response segments to represent separate concepts. For example, "The speed was consistent and put me in an area out of my comfort zone. After shooting the RHTTs, I felt myself get better. Also, I never saw one malfunction or break" was divided into three response segments, "The speed was consistent and put me in an area out of my comfort zone," "After shooting the RHTTs, I felt myself get better," and "Also, I never saw one malfunction or break." Because responses were broken down into response segments, the percentages below represent the percent of all response segments that fit in that category. That is to say, the percentages do not reflect the percent of users who made a particular type of comment, rather the percent of comment segments that reflected a particular theme. Researchers read through the responses for each question to identify common themes. After common themes were determined, two coders independently coded the comments using the identified themes.

The first open-ended question was "What was the most useful part of RHTT? What did RHTT do the best?" The responses were analyzed by researchers and eleven themes were

identified, see Table 6. Each statement was independently coded by two researchers. The interrater reliability was Kappa = .70. Discrepancies were resolved through discussion. One of the most common themes was on RHTT movement, with comments on movement divided into three categories: realism, variability and unpredictability, and other positive aspects, such as direction (e.g., lateral), of the movement. Another common theme was training scenarios, with comments divided into two categories: realism and other positive aspects, such as variety, of the scenarios. The third theme identified was RHTT speed, which was divided into two categories: variety and unpredictability, and other positive aspects, such as consistency of speed. Other common themes include the challenge provided by RHTT training, the feedback provided in RHTT training, the programmability of the RHTTs, and other comments that did not fit clearly into the other themes. The majority of Soldiers responded to this question, only 5.9% left this item blank.

Table 6

Responses to question "What was the most useful part of RHTT? What did RHTT do the best?"

Theme/Category	**Description**	**Percent of Responses**
Realistic Movement	The RHTTs had realistic movement like what you would expect to see from enemy units.	11%
Varied/Unpredictable Movement	RHTTs changed direction without warning during training and was difficult to determine which direction it would go.	11%
Other Movement	Positive aspect of the RHTTs movement unrelated to realism or variety of movement.	15%
Realistic Scenario	The training scenarios were realistic with respect to expectations from the field environment.	11%
Other Scenario	Positive aspect of the RHTTs use in scenarios, such as variety, unrelated to realism of scenarios.	5%
Varied/Unpredictable Speed	RHTTs speed changed and was difficult to predict how fast or slow it would move.	7%
Other Speed	Positive aspect of RHTTs speed, such as realism unrelated to variety.	6%
Challenging/Difficult	The RHTTs provided sufficient difficulty for training moving target marksmanship.	5%
Feedback	RHTTs provided valuable feedback to trainees about target hits/misses.	10%
Programmable	RHTTs were easy to set up and program as needed for a given training scenario.	4%
Other	Any comment that didn't fit an above category.	17%

The second open-ended question was "What did you like the least about RHTT?" Eight themes were identified. Two researchers independently coded the responses and had high interrater reliability, Kappa = .81. Discrepancies were resolved through discussion. The most common themes in response to this question were unrealistic movement, malfunctions, and limited feedback (see Table 7). Interestingly, the fourth most frequent theme was nothing – respondents wrote down that there was nothing they liked the least about the RHTTs, this was not respondents leaving the space blank. Approximately 24% of respondents did not answer this question.

Table 7
Responses to question "What did you like least about RHTT?"

Theme/Category	**Description**	**Percent of Responses**
Unrealistic Movement	The RHTTs did not have smooth human-like movement. It was too jerky or uneven at times.	21%
Malfunctions	RHTTs broke down too easily. Reset time takes too long. Long period of waiting around trying to resolve malfunctions. Delayed training.	17%
Limited Feedback	The RHTTs do not provide in-depth feedback regarding hit location. More specific feedback is desired.	16%
Nothing	Nothing was disliked about the RHTTs ("Nothing" or "NA" was the written response, does not include responses left blank).	12%
Speed Capabilities	The RHTTs moved too slowly and adjusting speeds was difficult/not possible mid-training.	5%
Quantity Available	There are not enough RHTTs currently available to use for training; should be used for training throughout the army.	2%
Weather Limitations	Weather caused Wi-Fi to go down making the RHTTs impossible to use unless weather conditions were favorable.	2%
Other	Any comment that didn't fit an above category.	24%

The third open-ended question was "List one improvement you would like to see made to RHTT?" Eight themes were identified. Two researchers independently coded the responses with high interrater reliability, Kappa = .95. Discrepancies were resolved through discussion. Responses to this prompt mirrored the responses to the previous question. The most common themes included improving the stability and movement of the RHTTs, the realism of response, the specificity of feedback, and reducing the need for technical support (see Table 8). Approximately 24% of respondents did not answer this question.

Table 8
Responses to prompt "List one improvement you would like to see made to RHTT."

Theme/Category	Description	Percent of Responses
Stability and Movement	Reduce wobbly/jerky movements. Less likely to fall down.	19%
Realistic Response	Response when fired upon (e.g., shooting back, taking cover, talking).	18%
Feedback	Hit location is not specific enough/needs improvement. Additional feedback on hit location.	17%
Technical Support	Difficult to set up and fix. Malfunction/breakdown too frequently and troubleshooting cuts into training time.	17%
Appearance	Variation in appearance (size, features, etc.)/more human-like.	9%
Nothing	Nothing was disliked about the RHTTs ("Nothing" was the written response, does not include responses that were left blank).	6%
Quantity	There are not enough RHTTs currently available to use for training; should be used for training throughout the army.	3%
Other	Any comment that didn't fit an above category.	11%

Discussion

Two types of survey data were collected. First, Soldiers in the capabilities demonstration rated their confidence in hitting moving targets before and after engaging RHTTs. Second, Soldiers in the other training exercises provided user feedback on the RHTTs.

All Soldiers who completed the Moving Target Skills Questionnaire showed changes in confidence after engaging RHTTs. Confidence levels should change in response to perceived task difficulty, to changes in expectations of task performance, and to monitoring of task performance (Dunlosky & Rawson, 2012; Schraw, 1996). As a result, changes in confidence ratings reflect the level of perceived training challenge or effectiveness. Increases and decreases in confidence are both informative. An increase in confidence may indicate that Soldiers feels that they have improved a skill. A decrease in confidence may reflect that Soldiers have recalibrated their estimate of their ability – for example, Soldiers may be very confident in their ability to hit moving targets before training with the RHTTs, but after training with the RHTTs they may realize that the task is more difficult than they realized and that they are not as skilled as they thought. Whether confidence increases or decreases, the change in confidence is informative because it suggests change in the perceptions of the task and/or their ability.

Most Soldiers agreed or strongly agreed that the RHTTs moved realistically and that engaging the RHTTs was realistic. Many Soldiers also commented on the realism when asked what they liked best about the RHTTs, though some Soldiers commented that the movement was

not as smooth as human movement and therefore, less realistic. Further research could examine which aspects of human movement are most important to capture for ideal target fidelity. The survey findings provide preliminary evidence that RHTTs provide target fidelity/realism.

Conclusions

The findings present a broad sample of information about RHTTs training realism and training effectiveness. While no single finding was in itself compelling, the sum of the findings converge on the conclusion that RHTTs provided challenging and realistic training that improved moving-target engagement skill. Experienced snipers and Infantry Soldiers significantly increased their proportions of moving targets hits after training with RHTTs. Likewise, USASC students who initially trained moving-target engagements with RHTTs significantly increased their likelihood of hitting walking targets. The fact that these groups with varying levels of shooting experience were able to improve their performance after practice engaging RHTTs suggests that even experienced shooters can benefit from the opportunity to engage realistic moving targets.

Soldiers' perceptions of the RHTTs training indicate that RHTTs had training utility, helped improve performance, and provided training realism. Generally, the movement of the RHTTs was praised along with the realism of the training. Though the movement of the RHTTs was considered one of the most useful aspects of this technology, improving movement, especially over uneven terrain, was a top area identified for improvement. Also, though approximately 10% of responses mentioned the feedback as a useful feature, many Soldiers identified specific feedback on hit location high on the features that need improvement. Overall, perceptions of the RHTTs appear to generally be positive as seen by responses on the Likert-type question but also in the responses to the open-ended questions.

Another salient finding was that overall ability of all Soldiers who engaged the RHTTs to hit realistic moving targets was low. The proportion of hits on RHTTs for all Soldiers shooting scored events was only about 50%. In addition, Soldiers shooting complex scenarios (i.e., individual snipers) hit RHTTs with only 21% of the rounds fired. These metrics do not compare to the performance on traditional walking targets. The overall proportion of hits on walking targets by USASC students was over 62%. The difficulty hitting RHTTs reflects the difficulty of engaging moving targets in combat reported by Dyer (2015) and Ehrhart (2009). Because engaging moving targets represents a human-performance challenge, training must reflect the realities of these specific challenges, i.e., responding to natural movement in multiple directions and the need to "react" to the situation. The capability for RHTTs to provide training was evident in Soldiers' reports of their skill confidence. All Soldiers reported a change in their confidence after engaging the RHTTs. This suggests that Soldiers were recalibrating their perceptions of their abilities in response to their performance with more realistic moving targets.

As with any training system, the goal of moving-target systems should be to provide trainees with an immersive experience in which to practice and improve skills (Knerr, et al., 1998). While the findings reported here suggest that RHTTs provided more realistic training than traditional moving-target systems (e.g., walking targets), the far-impact, such as on combat performance, could not be examined.

Last, it is important to remember that the RHTTs are a training tool. The effectiveness of a training tool depends on how it is used in learning and practice. Training Soldiers using a new capability is not sufficient to ensure that skills are acquired or retained. As such, it is important to use findings from behavioral science research on training, such as the utility of feedback or the use of guided practice to improve training (Salas et al., 1998). It is also important to ensure that training devices are used in a way that lead to improvements, which requires tracking how a training device is used and how performance changes over time (Bink, James, & Uhl, 2015).

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Appendix A. Background Information Questionnaire

Please write-in, circle, or fill in the dot (•) for each question.

1.	Rank _____

2. Unit _____

3. Current Time in Service	Years _____	Months_____

4. Number of Deployments	_____

5. Year of Last Deployment (circle most recent)	Prior to 2011	2011	2012	2013/2014

6. When was the last time you engaged moving targets in training in the last 12 months? (check (•) one)		
a	Have not engaged moving targets in training in the last 12 months	○
b	Less than 1 week	○
c	Less than 1 month	○
d	Less than 6 months	○
e	Greater than 6 months	○

7. How many times have you engaged moving targets in training in the last 12 months? (check (•) one)		
a	Have not engaged moving targets in training in the last 12 months	○
b	Once or twice	○
c	3 to 10 times	○
d	More than 10 times	○

8. How many times have you engaged a moving target in combat? (check (•) one)		
a	Have not engaged moving targets in combat	○
b	Once or twice	○
c	3 to 10 times	○
d	More than 10 times	○

Appendix B. RHTTs User Survey

Instructions: For each item, respond by checking the box that best indicates how much you agree with each statement.

	Strongly Disagree	Disagree	Agree	Strongly Agree
1) RHTT allowed training that is not now or not easily conducted in marksmanship training.	□	□	□	□
2) Training with RHTT improved your individual task performance (lateral engagements, oblique engagements, etc.).	□	□	□	□
3) RHTT helped you make sound engagement decisions.	□	□	□	□
4) Feedback given by RHTTs was useful for improving your skill.	□	□	□	□
5) RHTT provided challenging training.	□	□	□	□
6) Training with RHTTs made your unit more prepared to conduct similar live missions.	□	□	□	□

Instructions: Considering the training scenario you just completed, indicate how much you agree with each statement. Respond by checking the appropriate box.

	Agree	Somewhat Agree	Somewhat Disagree	Disagree
7) The RHTTs moved in a realistic manner.	□	□	□	□
8) The scenario was realistic.	□	□	□	□
9) The scenario was challenging.	□	□	□	□
10) Engaging the RHTTs was challenging.	□	□	□	□
11) Engaging the RHTTs was realistic.	□	□	□	□
12) Based on this scenario, having RHTT capability will be important for unit training.	□	□	□	□
13) Training with RHTT provided sufficiently realistic conditions in which to train moving targets.	□	□	□	□
14) The RHTTs enhanced my ability to hit moving targets in this scenario.	□	□	□	□

15) Instructions: In what training environments would RHTT be useful? Please mark "yes" or no".

	Yes	No
Individual Tactical Skills	□	□
Squad Battle Drills	□	□
Squad Live Fire	□	□
Squad MOUT	□	□
Platoon Battle Drills	□	□
Platoon Live Fire	□	□
Platoon MOUT	□	□
Buddy Team Live Fire	□	□
Individual Training at Schoolhouse (Functional Courses)	□	□
Individual Training and Schoolhouse (PME Courses)	□	□
OSUT/BCT	□	□

16) What was the most useful part of RHTT? What did RHTT do best?

_____
_____
_____

17) What did you like the least about RHTT?

_____
_____
_____

18) List one improvement you would like to see made to RHTT.

_____
_____
_____

Appendix C. Moving Target Skills Questionnaire

Moving Target Skills Questionnaire

Instructions: For each item, indicate *How Confident* you are in your ability to execute the skill. Respond by checking the box that best indicates your level of confidence.

		Not Confident	Somewhat Confident	Mostly Confident	Extremely Confident
1)	Determine range to stationary targets	☐	☐	☐	☐
2)	Hit stationary targets	☐	☐	☐	☐
3)	Determine range to laterally moving targets	☐	☐	☐	☐
4)	Hit laterally moving targets	☐	☐	☐	☐
5)	Determine range to obliquely moving targets	☐	☐	☐	☐
6)	Hit obliquely moving targets	☐	☐	☐	☐
7)	Determine range to targets moving directly towards you	☐	☐	☐	☐
8)	Hit targets moving directly towards you	☐	☐	☐	☐
9)	Determine range to targets moving directly away from you	☐	☐	☐	☐
10)	Hit targets moving directly away from you	☐	☐	☐	☐
11)	Determine range to human targets moving at 10 miles per hour	☐	☐	☐	☐
12)	Hit human targets moving at 10 miles per hour	☐	☐	☐	☐

Appendix D. Sniper Moving Target Record Fire Scenario

SNIPER FIRING TABLE II
STATIONARY AND MOVING KNOWN DISTANCE TARGETS
M24--DAY
(MIL-DOT RETICLE SCOPE AND AN/PVS-10)

For use of this form, see FM 3-22.10; the proponent agency is TRADOC.

EXERCISE NUMBER *(CHECK ONE)*	QUAL 1 ☐	QUAL 2 ☐	RETRAIN ☐	QUAL 3 ☐

SNIPER NAME	LANE	DATE *(YYYYMMDD)*

SPOTTER NAME	UNIT	WEATHER/VISIBILITY

SCORING CHART

The sniper fires one round at each target presented. The trainer marks all of the sniper's hits and misses, and then totals the hits.

RANGE (M)	TYPE[a]	HITS	MISSES
300	S		
300	M		
300	M		
300	M		
300	M		
400	S		
400	M		
400	M		
400	M		
400	M		
500	S		
500	M		
500	M		
500	M		
500	M		
600	S		
600	M		
600	M		
600	M		
600	M		
	TOTAL HITS		

RATING CALCULATOR

TOTAL HITS x 5 = TOTAL POINTS:

RATING SCALE

70 TO 100 TOTAL POINTS = PASS ☐

0 TO 65 TOTAL POINTS = FAIL ☐

LEGEND

a. "S" means the target is stationary; "M" means it is moving.

b. Sniper School only: Sniper initials below to acknowledge that -

- He has received mentoring on performance.
- He has been given the opportunity to choose a new spotter.

TRAINER'S INITIALS	DATE *(YYYYMMDD)*	SNIPER'S INITIALS [b]	DATE *(YYYYMMDD)*

DA FORM 7644-R, NOV 2009

DA FORMS 7643-R, 7644-R, 7645-R AND 7646-R REPLACE DA FORMS 7329-R AND 7330-R, WHICH ARE OBSOLETE.

APD LC v1.00