Recent Advances in Ground Vehicle Target Simulators and Surrogates

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Abstract

There have been recent advances in low-cost target surrogates for T&E that have been successfully validated and accredited for use by certain programs. These targets can bridge the gap between non-realistic, "whatever's handy on the range" targets and actual threat vehicles by providing test-specific signature elements to meet validation and accreditation requirements and avoid the need to use real threat vehicles. The US Army's Targets Management Office (TMO) has successfully developed, validated, and deployed gunnery targets for T&E under the Threat Vehicle Surrogate Target (TVST) program. Current target development programs such as the Precision Target Signatures (PTS) program and the Realistic Low Cost Targets (RLCT) program are leveraging lessons learned on the TVST program to increase the fidelity, durability, and utility of validated targets for T&E while simultaneously lowering the cost. This paper will cover the recent development history of targets developed for T&E applications by TMO on these three programs.

1. INTRODUCTION

Modern weapon systems are continually pushing the envelope in sensor resolution and operator battlefield awareness. Proper stimulation of these sensors is critical in the Test & Evaluation (T&E) phase to ensure that the weapon systems under development perform acceptably when they go into battle with the warfighter. Since the whole purpose of a weapon system is to detect, identify, engage, and destroy a threat, realistic threat targets are critical to the world of T&E and threat ground vehicle targets are the ones where the rubber meets the road (literally) on modern battlefields. Even with the current focus on the danger of improvised explosive devices, threat ground vehicles such as main-battle tanks, infantry fighting vehicles, and armored personnel carriers are still recognized as the primary targets of interest for many US weapon system development programs.

Unfortunately, threat ground vehicle target technology for T&E has simply not made the advances that sensor systems and platforms have made over the last few decades. For many T&E scenarios of the recent past, the only way to get an accredited target for a test to support an acquisition milestone decision was to use actual threat vehicles with all of their associated costs, long acquisition lead times, and logistical burdens. There have been cases where surrogate targets have been successfully brought into play, but due to time constraints, there are also instances where surrogate target development efforts may not be completed in a timely manner to meet identified T&E requirements. This situation places test designers for the system under test in the classic quandary of having to meet high target signature fidelity requirements with limited budgetary resources.

The signature fidelity history of ground targets for T&E is extremely bi-modal. Targets are usually either something fabricated on a test range or they're actual threat vehicles. The first option provides for a low-cost approach to providing targets for testing with varying (usually low) levels of signature fidelity. The second approach using real vehicles provides testers with high confidence that the threat representations are valid but at a significant, and often prohibitive, cost. However, there have been recent advances in low-cost target surrogates for T&E that have been successfully validated and accredited for use by certain programs. These targets can bridge the gap between non-realistic, "whatever's handy on the range" targets and actual threat vehicles by providing test-specific signature elements to meet validation and accreditation requirements and avoid the need to use real threat vehicles.

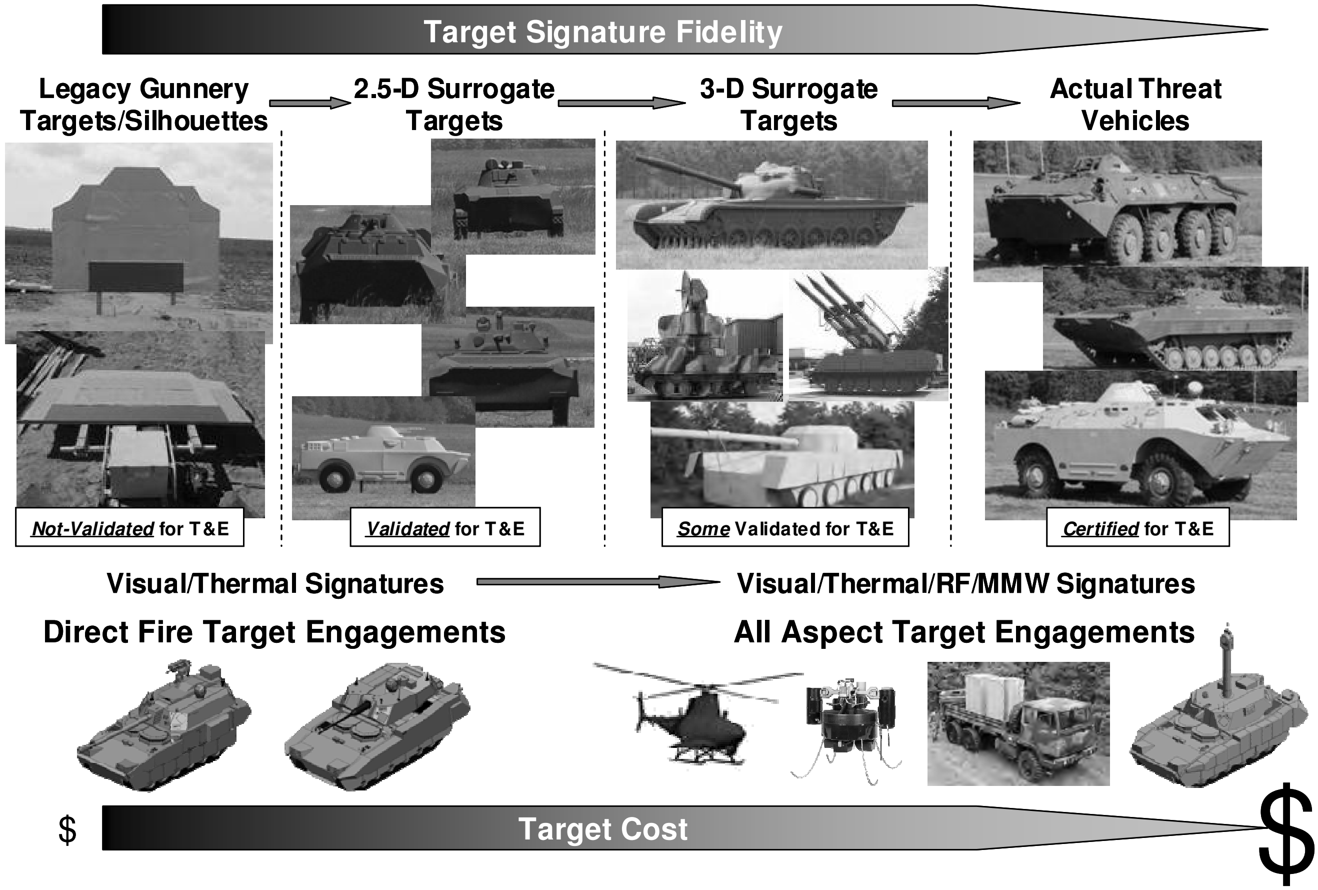

Figure 1: Ground Target Signature Fidelity/Cost Continuum

The types of targets needed for a test depend primarily upon the geometry of the sensor/shooter/target engagement and cost savings can be realized by understanding target signature requirements and designing targets to satisfy specific test needs. Figure 1 shows the ground target signature fidelity/cost continuum and demonstrates the constantly increasing cost associated with increasing signature fidelity. Starting on the left of the figure are common target silhouettes as specified by Army field manual FM-17-12-1 for use in gunner training. These targets are inexpensive, easily fabricated as-needed at gunnery ranges, but offer almost nothing in the way of threat representative visual and thermal infrared (IR) signatures. Until recently, these were the primary option for weapon platform sensor stimulation on gunnery ranges.

On the far right of the figure are actual threat vehicles which only need to be certified as actual threats to be accredited for T&E use. In between these two extremes are targets of varying complexity, some of which have been validated for T&E. The 2.5-dimensional (2.5-D) target surrogates shown are targets that were designed for use by the Expeditionary Fighting Vehicle (EFV) program during gunnery Operational Testing (OT). These targets are limited to use on target lifters on gunnery ranges but they are capable of presenting very realistic visual and thermal infrared (IR) signatures over a limited range of angles. Thanks to their inherent realism, they were able to be validated for use in T&E and represented an over $10M cost avoidance for the EFV gunnery OT. More complex, multi-aspect target engagements require full three-dimensional (3-D) surrogate targets and there are examples of these in DoD inventory with IR and radio frequency/millimeter wave (RF/MMW) signatures that have been validated for use in T&E activities.

2. THREAT VEHICLE SURROGATE TARGETS PROGRAM OVERVIEW

The 2.5-D targets shown in Figure 1 are known as the Threat Vehicle Surrogate Targets (TVSTs). These targets were developed by the US Army's Targets Management Office (TMO) for the Marine Corps Operational Test and Evaluation Activity (MCOTEA) to meet the specific needs of the EFV gunnery OT. These targets were designed in collaboration with the National Ground Intelligence Center

(NGIC) and were developed utilizing NGIC threat data and 3-D geometry and IR signature models. Getting NGIC involved in the early stages of the TVST design process greatly helped with the validation of the target's signatures, as NGIC has to concur that the surrogate target signatures are representative of the threat target signatures. Even with the additional cost of satisfying the DA PAM 73-1 Threat Simulator Validation Process, the entire TVST design, validation, and deployment process only cost on the order of $1M which was more than an order of magnitude less than the estimated $12M+ cost of meeting EFV gunnery OT requirements with actual threats. The TVSTs were made from vacuum-formed ABS plastic and the target shells were fabricated by a US Navy facility at Patuxent River Naval Air Warfare Center. These shells were then attached to wooden frames and from there to the mechanical gunnery range lifters. If a particular test required targets with IR signatures, a thermal signature kit could be added to the interior of the target shell to provide a validated IR signature. A total of six types of TVSTs were created and Figure 2 shows two of them, the BTR-70 frontal target and the BRDM-2 starboard flank target.

The upper half of Figure 2 shows an actual BTR-70 and a BTR-70 frontal TVST photographed from a distance during the TVST signature validation test. Both targets are facing the same direction and the photographs were taken within a minute of each other. As can be seen in the pair of photographs, a large piece of vacuum-formed plastic can interact with natural sources of illumination and create a very convincing threat vehicle visual signature for a limited range of viewing angles to meet gunnery OT requirements.

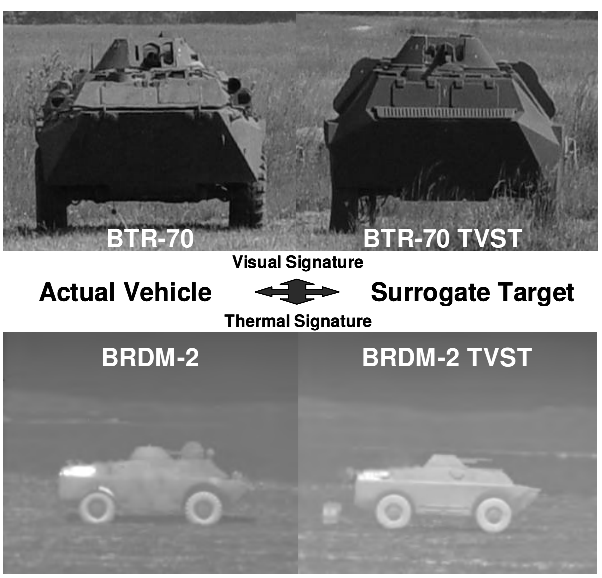

Figure 2: TVST 2.5-D Visual and Thermal Signature Comparison to Actual Threat Vehicles

The bottom half of Figure 2 shows a thermal image pair of an actual BRDM-2 and the BRDM-2 starboard flank TVST. Once again, it is immediately apparent that a properly designed target surrogate can create a realistic threat signature. The TVST IR signature capabilities included the different vehicle operational states of cold, idling, and exercised, although only the exercised IR signature case was used in EFV gunnery OT.

The TVSTs represent a highly successful target surrogate program that was able to help get a major developmental weapon system past an acquisition milestone. However, the TVSTs are not without their limitations and other developmental platforms will require different target technologies in order to create realistic ground vehicle target surrogates. Of particular concern is the looming transition to multi-spectral and hyper-spectral sensors that will have an entirely new set of requirements unaddressed by the TVST program. Nevertheless, the TVSTs were more than sufficient to meet the intended user's test requirements at the time and is still being used for various scenarios.

3. PRECISION TARGET SIGNATURES PROGRAM OVERVIEW

The Precision Target Signatures (PTS) program was initiated by TMO in 2006 to explore concepts in leveraging commercial display manufacturing technologies for target surrogate development. The PTS target development concepts were derived from initial Realistic Low Cost Targets (RLCT) program concepts that showed exceptional promise. TMO accelerated and focused target development efforts on the PTS program to determine the feasibility of manufacturing targets using specific materials and techniques.

PTS program targets are fabricated using materials and processed adapted from the point of purchase (POP) display industry. A gunnery or range target can be thought of as simply an outdoor display of a target signature, and there are materials used in the outdoor display industry that have material properties suitable for target fabrication. POP displays, which are ubiquitous in the modern retail environment, can take a variety of shapes and be very structurally sound and self-supporting. Outdoor display materials, combined with POP display design techniques, were utilized in the design and manufacturing of the PTS targets.

The PTS program initially started with the design and prototyping of 2.5-D gunnery targets and after initial successes expanded into the development of full-scale three dimensional (3-D) targets. Figures 3 and 4 show examples of the PTS program 2.5-D target prototypes. The first target designed was a 1/3rd-scale T-72 frontal target made of corrugated paper with photographs of a real T-72 digitally printed onto the corrugate. This target was cut out on an X-Y cutting table and assembled by hand. The high visual fidelity of this target provided impetus to continue exploring this target technology and the next stage was a production run of two hundred 1/10th-scale targets. These targets utilized the large scale production techniques of rotogravure printing and die cutting. Photos of these two sub-scale targets are shown in Figure 3.

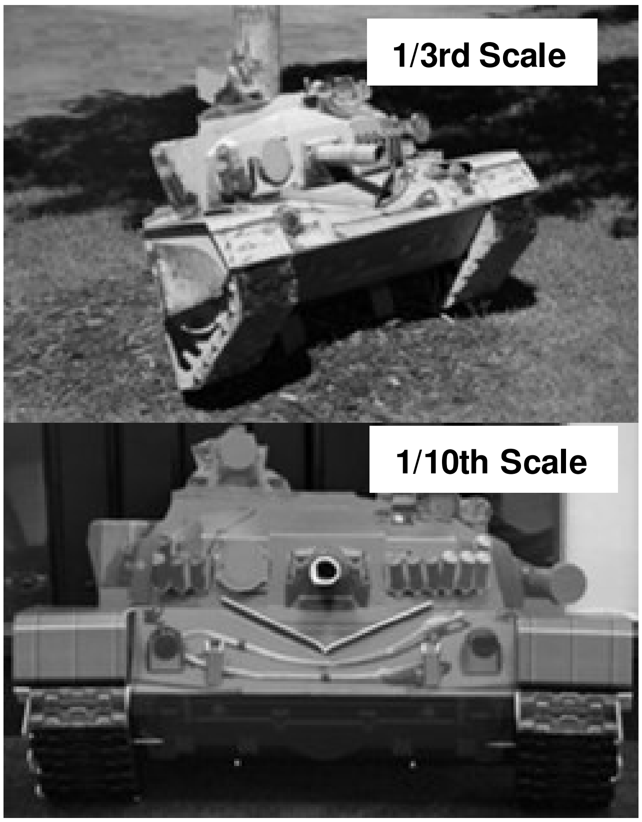

Figure 3: Sub-Scale PTS Prototypes

Development of a full-scale 2-5-D target suitable for outdoor use was the next step in the PTS program after the success of the sub-scale targets. The material of choice for many outdoor displays is Coroplast (corrugated polypropylene plastic) which is available in a variety of colors and thicknesses. In addition, it is compatible with modern commercial printing processes such as screen printing and flatbed digital printing. Corrugated paper, while extremely inexpensive, simply cannot withstand moisture, therefore an environmentally durable material such as Coroplast is required for outdoor range targets.

Figure 4 shows photos of the full-scale PTS T-72 2.5-D frontal target; both folded up for shipment and assembled. The target was fabricated out of flat sheets of Coroplast that were digitally printed with artwork and then cut out. The target was designed so that it could be folded for shipping and storage yet easily deployed. This target utilized a plywood backing for compatibility with range scoring systems that require vibration sensing, as Coroplast is so ballistically transparent and flexible that impact vibrations would not be transmitted to the hit sensors.

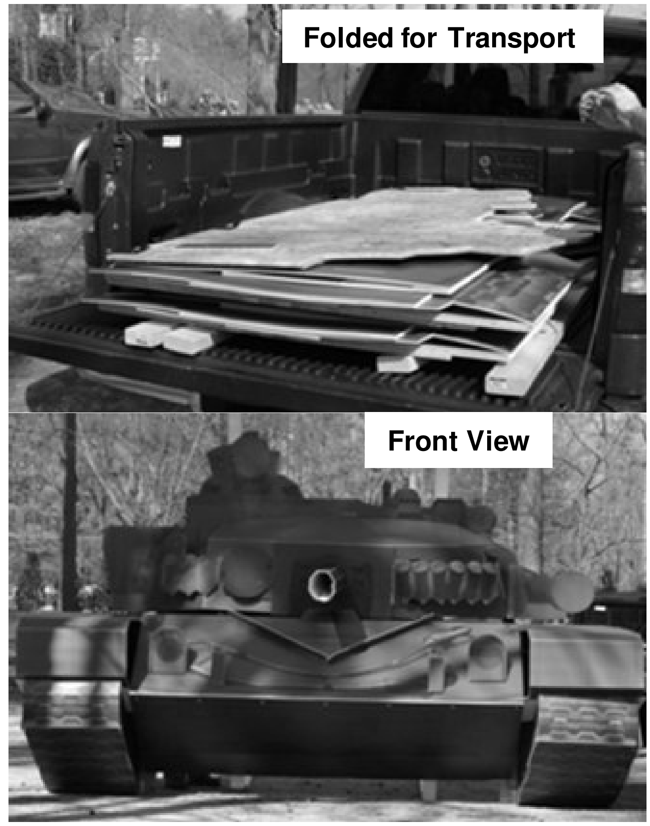

Figure 4: Full-Scale PTS T-72 2.5-D Frontal Target

The setup time for the full-scale T-72 frontal target was on the order of 15 minutes with two people. This rapid deployment time combined with the visual fidelity of the printed artwork on the target and the overall shape and level of detail resulted in a very viable, high-fidelity target design.

After success with the 2-5-D target feasibility studies, the PTS program scope was expanded to 3-D targets. Initial efforts involved 1/5th-scale prototyping followed by full-scale prototyping and an initial production run. The targets that were prototyped were the T-72 and T-90. The advantage of choosing these targets is that the T-90 is simply a more modern, accessorized version of the T-72 and it is possible to convert a T-72 target surrogate into a T-90 target surrogate but simply exchanging external accessories. Figure 5 shows photos of the T-72 full-scale prototype and a full-scale T-90 initial production unit.

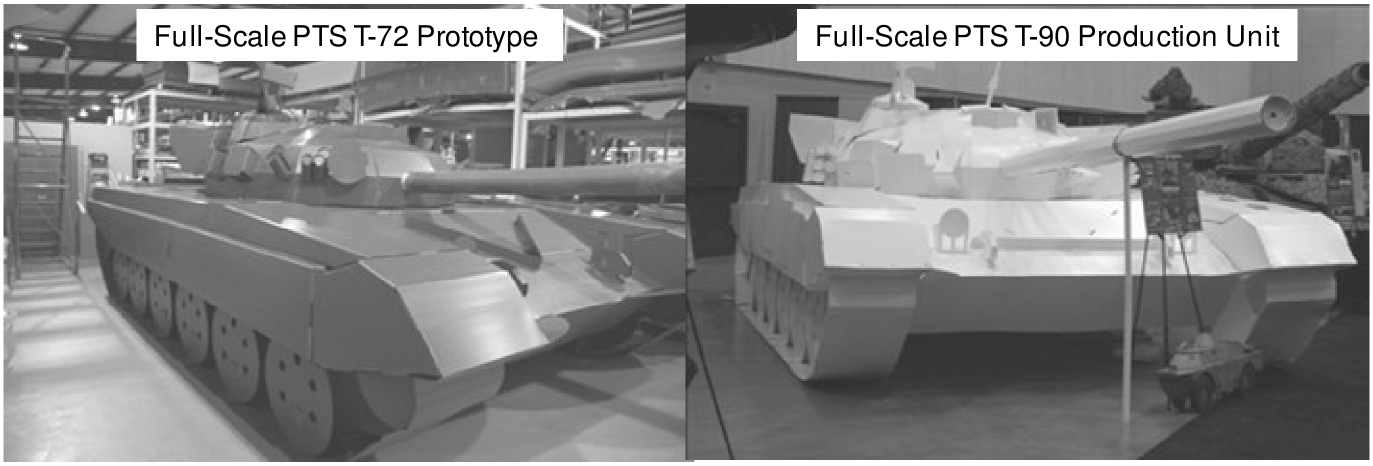

Figure 5: Full-scale PTS T-72 and T-90 Targets

The full-scale 3-D PTS target proved to be highly durable, man-portable (4-6 man lift), and very realistic. The only detractor from the initial 3-D PTS design was an unacceptably long setup time of multiple man days. This long assembly time is understandable because the PTS target is in essence, a complex, twenty foot long, twelve foot wide, and eight foot tall 3-D puzzle. In order to address this assembly time concern, the full-scale PTS targets are being re-designed from the ground up to include partial pre-assembly at the factory to minimize setup time in the field.

4. REALISTIC LOW COST TARGETS PROGRAM OVERVIEW

The RLCT program is a follow-on program to the TVST program to address lessons learned during the deployment of the TVSTs. As successful as the TVSTs were, there were issues with durability of the ABS plastic, the amount of extra labor and materials required to frame and deploy the targets, target disposal, and logistics in general. Since the TVSTs were developed starting with an assumed material and manufacturing process, it was desired to perform extensive research into alternative materials and processes to determine an optimum approach to gunnery target fabrication.

The RLCT program began with extensive research into every possible target material and manufacturing process. In an effort to be as exhaustive as possible, hundreds of materials and dozens of manufacturing processes were investigated as candidates. After feasible materials and processes were selected, over a hundred target design concepts were developed and evaluated using a multi-stage, seven-dimensional trade study. Both 2.5-D and 3-D targets were included in the analysis and a small number of winning manufacturing solutions were selected for each target dimensionality. The one manufacturing approach that was common to both the 2.5-D and 3-D manufacturing feasibility studies was folded Coroplast targets such as those developed under the PTS program. Therefore, the RLCT program progressed into target design and prototyping utilizing the folded Coroplast fabrication approach.

The 2.5-D targets being designed for the RLCT program are shown in Figure 6. The targets include a T-72 frontal, a BMP-2 frontal and flank, and a BRDM-2 flank target. Much like the TVSTs, the RLCT designs are intended for use on target lifters in gunnery range target pits. The advantages of the RLCT designs over the TVSTs include:

- Lighter weight
- Faster setup time with no special tools or extra materials required
- Easier and less expensive shipping
- Greater durability
- Greater depth for enhanced visual signature
- Greatly simplified flank IR signature kits
- Option for high-fidelity thermal kit that incorporates nighttime diurnal signature effects
- Easier disposal and 100% recyclability of target structure

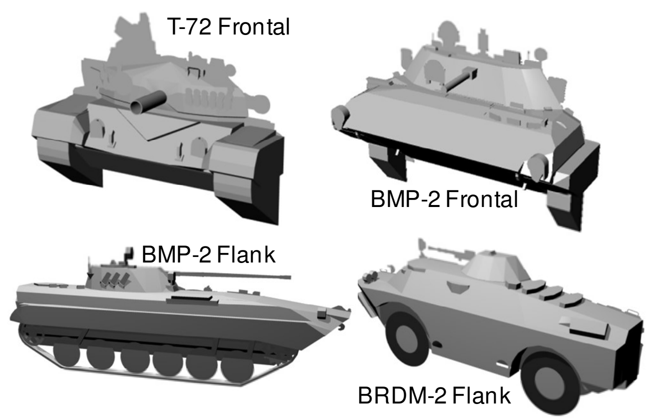

Figure 6: RLCT Target Concept Designs

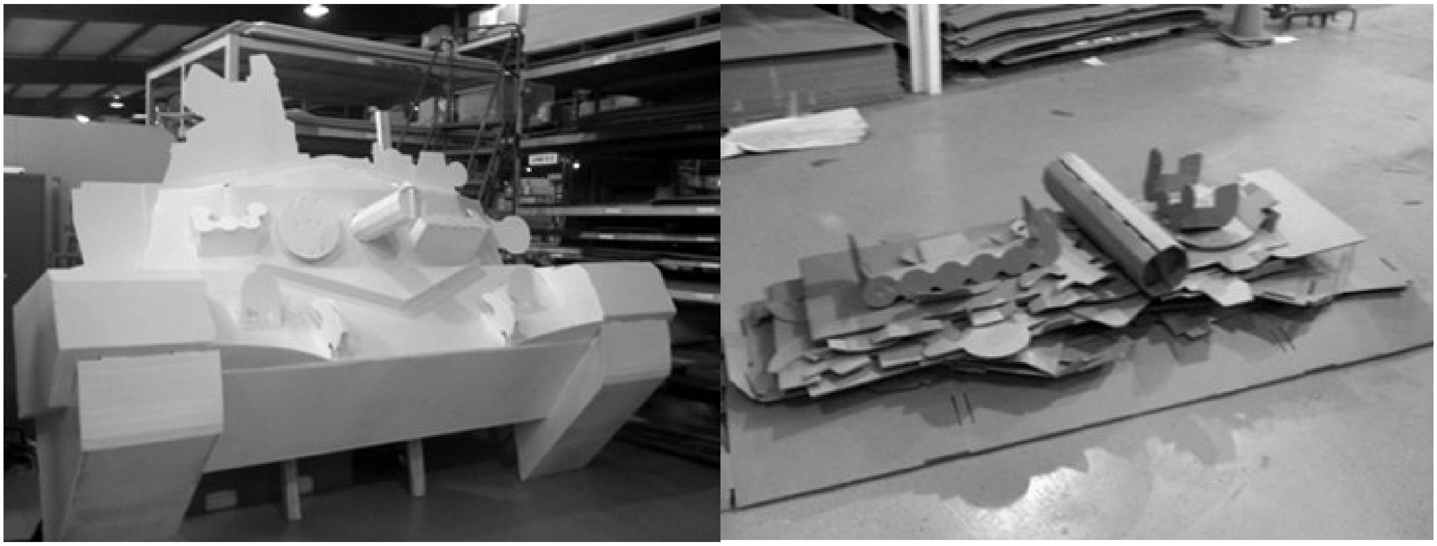

Figure 7: RLCT T-72 Frontal Target: Assembled, and Knocked Down Flat for Shipping

Figure 7 shows the initial RLCT T-72 full-scale prototype in both assembled form and knocked down flat for shipping. The estimated weight of the target is thirty pounds and is easily man portable with two people. The target was specifically designed for rapid setup based on the assembly difficulty lessons learned from the PTS program. Estimated assembly time of the target in Figure 7 is fifteen minutes or less with two trained personnel. Disassembly time has been measured at less than 10 minutes.

5. SUMMARY & CONCLUSIONS

Ground vehicle surrogate targets have the potential to represent a huge cost avoidance for T&E by replacing actual threat vehicles for specific tests. Real threat vehicles will never be completely replaced in the T&E world but the TVST program was an example of where they could be replaced with a much less expensive alternative to meet a specific test need. The follow-on RLCT program is leveraging lessons learned on the TVST program to create even higher fidelity targets for gunnery OT and plans are to validate their visual and IR signatures for accredited use by developmental DoD programs. The PTS program is developing full-scale 3-D targets for a wide range of uses including weapon system OT and man-in-the-loop force-on-force scenarios. The RLCT and PTS targets are the result of extensive research and development efforts by TMO and represent the current start of the art in low-cost target surrogates with a minimal logistical footprint.

Biographies

Jeffrey S. Sanders – Jeffrey S. Sanders is a Principal Engineer at Trideum Corp. in Huntsville, AL. He supports the TMO in the area of target surrogate visual and IR signature design and threat target signature validation and certification. He has also managed the IR signature modeling component of NGIC's Simulated Infrared Earth Environment Lab (SIREEL) program. Dr. Sanders received a BSEE, MSEE, and a PhD in engineering from Memphis State University in 1987, 1990, and 1994 respectively.

Robbin Finley - Ms. Robbin Finley is the project director for the Mobile Ground Target and the Virtual Targets Programs at the Targets Management Office; Program Manager for Instrumentation, Targets, and Threat Simulators; Program Executive Officer for Simulation, Training, and Instrumentation. Ms. Finley has fifteen years of acquisition experience, including assignments at the Multiple Launch Rocket System Project Office and the Software Engineering Directorate at the Aviation and Missile Command. Ms. Finley graduated from the University of Alabama in Huntsville with a Bachelor of Science degree in Electrical Engineering.