Cost Effectiveness of Embedded Training On Army Ground Vehicles

L. Bruce McDonald, Ph.D.
McDonald Research Associates, Inc.

Hubert Bahr
U.S. Army Simulation,
Training, and Instrumentation Command

Claude Abate
Madison Research Corporation
Orlando, Florida

Abstract

This paper describes the cost and operational effectiveness analyses being conducted on the STRICOM Embedded Simulation program. The program is developing Embedded Simulation (ES) to support Embedded Training (ET) and Embedded Operations (EO) for Army ground vehicles. The near term target for this program is the M1A2 SEP Abrams main battle tank. The basic approach to this cost effectiveness analysis is to determine the costs of various live training exercises and compare these costs to those that would be incurred using ET technology. Live training costs include operation and maintenance costs for the trainees' vehicles, other blue forces (BLUFOR) vehicles and for the opposing force (OPFOR) vehicles, as well as for range operation costs. The authors have gathered data on miles driven for various training exercises (e.g. Hasty Attack) as well as detailed operating costs (e.g. O&S Class IX Parts, Petroleum, Oil and Lubricants (POL), and Intermediate Maintenance) for the Abrams Tank and Bradley Fighting Vehicles. These data were derived from the OSMIS (Operating and Support Management Information System) database. OSMIS is the U.S. Army's source of historical operating and support cost information for tactical units. With this information, we were able to calculate the costs of various live training exercises. We then calculated the costs of equivalent exercises using ET technology. During embedded training exercises, some vehicle components are active and other components are not. Consequently, we were able to calculate the operating costs of vehicles during various types of embedded training exercises (moving, vehicle stationary, turret stationary). This allows us to predict the relative cost effectiveness of embedded vs full-up live exercises without making the naïve assumption that embedded training costs nothing. These cost savings are compared to ET acquisition costs to determine the payback period. These costs are expected to decline over time as the state-of-the-art produces smaller, faster and cheaper computers and displays. This paper discusses the results of this cost effectiveness analysis.

Biographical Sketch:

Bruce McDonald has been working in the area of Embedded Training since 1988 and has over 25 years of experience in modeling, simulation and training systems. He received his Ph.D. in Industrial Engineering from Texas A&M University in 1973. He is conducting the cost effectiveness analyses on the STRICOM Embedded Simulation program. He is charged with determining when the state-of-the-art in embedded simulation will be sufficiently robust to reduce the costs of live training in Army ground vehicles while providing equal or superior training effectiveness. His research interests are in embedded training, advanced distributed learning, small scale contingencies and force protection.

Hubert Bahr is a Decorated Vietnam Veteran with 28 years of Federal Service. He received his BS degree in engineering from the University of Oklahoma in 1972 and his Masters Degree in computer engineering from the University of Central Florida in 1994. For the past 18 years he has been involved with instrumented Force-on-Force Ranges. He is currently the lead engineer for the STRICOM Embedded Simulation program in the Research and

Engineering Directorate of STRICOM. His research interests are in the areas of parallel processing, artificial intelligence, and computer architecture. He is also pursuing his Ph.D. at the University of Central Florida.

Claude Abate is a Senior Military Analyst for Madison Research Corporation, and is currently supporting the Simulation Technology Division, Research and Engineering Directorate of STRICOM. He is a graduate of Florida Southern College and has a Masters of Science Degree from Florida State University. Prior to joining Madison, Mr. Abate was a career Army officer with a variety of command and staff assignments in the US and overseas. As a retired Colonel, his experience includes a perspective as a training and doctrine developer and Training Brigade Commander at the US Army Armor Center and School and as an opposing force commander at the National Training Center. He has two years experience working with PM CATT on the Close Combat Tactical Trainer and is currently the project coordinator for STRICOM Embedded Simulation program. His military schooling includes the Command and General Staff College and the Army War College.

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Introduction

To fight and win on the modern battlefield two things are required; weapons systems that out perform the opponent's weapon system, and crews that are better trained to use the weapon system effectively. A cost effective means of fulfilling both of these requirements is Embedded Simulation (ES), which includes Embedded Training (ET) and Embedded Operations (EO). ET provides warfighters with the capability to train and maintain crew proficiency on the same equipment they will go to war on. EO provides improved situational awareness (SA), mission rehearsal (MR), command coordination (CC), critical decision making (CDM) and course of action analysis (COAA) capabilities. This paper will concentrate on the ET aspects of embedded simulation. To date, stand alone trainers have been employed at the school house and in the units for initial and sustainment training. The power projection army of the future will have to spend more time maintaining task proficiency at a deployment site where the logistics costs of moving and supporting stand-alone trainers cannot be justified.

Embedded training technology will allow crew members to practice the operation of groups of vehicles while using the actual vehicle controls, but at a reduced operating cost. While it is tempting to assert that embedded training technology can reduce Army operating tempo (OPTEMPO) costs, these budgets are already woefully inadequate. It is hoped that the reduced costs of operating vehicles using embedded simulation can be used to expand training opportunities within limited budgets as opposed to justifying reduced OPTEMPO budgets.

STRICOM Embedded Simulation Program

The goal of this program is to develop and demonstrate an in-vehicle distributed simulation capability employing reusable common components with interfaces to system-unique components; along with tutoring and after action review systems, take-home packages, and scenarios. This Science & Technology Objective (STO) is developing and demonstrating the technology needed to fully embed an advanced distributed simulation system in ground combat vehicles for the Army 2010 and Beyond. The STRICOM ES program is evolving an architecture suitable for implementation of ES in future and legacy vehicles. The program objective is to demonstrate the feasibility of using ES to enhance future training & operational capabilities for individuals and crews up to the Battalion/Task Force level. The ES concept uses data provided by digitized systems and enhances data presentation.

STRICOM has developed an architecture consisting of a B-Kit with common embedded simulation components and an A-Kit with components that are required to interface with vehicle-specific power, computers, controls and displays. The ES system will inject targets into the vehicle sights, sensors and display systems. These targets will be intelligent and will be coordinated such that multiple vehicle operators will be able to view the same targets. The system will utilize Commercial Off-the Shelf (COTS) hardware, which is being driven by the commercial gaming industry to become increasingly more cost effective

The primary tool for conducting training in the Army is the Army Training and Evaluation Program (ARTEP) & Mission Training Plan (MTP). The ARTEP for Abrams-equipped tank platoons is ARTEP 17-237-10

MTP (Mission Training Plan for the Tank Platoon) (U.S. Army, 1998). This MTP provides the tasks, conditions and standards to develop a tank platoon training program. Consequently, the primary target of ET for tank platoons must be ARTEP 17-237-10-MTP. See McDonald and Bahr, (1998) for a more detailed discussion of the ARTEP tasks that can be trained using ET. ET can be used to train almost all of the ARTEP tasks, especially the Command, Control, and Communication, Maneuver and Air Defense tasks.

Costs of Live Exercises

This cost effectiveness analysis addresses two modes of ET, virtual targets displayed on virtual terrain with the vehicle stationary (Mode 1), and virtual targets displayed on the live terrain with the vehicle moving (Mode 2).

M1A2 Operating Costs

Since the near term target of ET is the M1A2 Abrams System Enhancement Package (SEP), we have obtained detailed operating expenses for the M1A2 tank at Ft. Hood from the OSMIS (Operating and Support Management Information System) data base. OSMIS is the U.S. Army's source of historical operating and support cost information for tactical units. This data base contains the costs of consumable and repairable parts (Operations and Support Class IX) for all U.S. Army systems. This data is tracked down to Work Breakdown Structure (WBS) level 4. The total O&S Class IX costs for vehicles are then divided by the total miles driven to derive the average cost per mile for each WBS item. Table 1 columns 1 and 2 list the M1A2 WBS numbers and names; and column 3 indicates the cost per mile at Ft. Hood in second quarter FY98. The reader can see that the total O&S Class IX parts cost for the M1A2 Abrams is $432 per mile. We then made a judgement as to which of these components would be in operation with the vehicle stationary during a Mode 1 ES exercise. For example, since the main gun will not be fired in a Mode 1 exercise, the support costs for the main gun will be zero. But the electrical system will be powered up during the simulation of each mile of an exercise, and the support costs for the electrical system will be equal to the moving support costs (as a worst case assumption). In some cases, the WBS item is labeled as Other. It was assumed that the Mode 1 ES costs for Other would be half of the live operations costs for that WBS. Column 4 of Table 1 contains the estimated O&S Class IX parts costs for ET exercises in Mode 1. ET exercises in Mode 1 can be conducted for $126/mile, which is 29% of the cost of a live exercise.

Table 1
M1A2 Abrams Tank
Relative O&S Class IX Costs
Of Live Vs. Virtual ET Exercises

WBS	WBS Name	Live Exercise Cost Per Mile ($)	Virtual ET Exercise Cost Per Mile ($)
01A	Structure	29.68	
01C	Towing and Lifting Fittings	0.04	
01E	Hatches	0.14	
01F	Grilles	0.97	
01H	Other	9.56	
02A	Wheels	7.68	
02B	Tracks	22.13	
02F	Springs	0.04	
03A	Engine	197.92	
03E	Controls and Instrumentation	0.56	
03G	Cooling Means	0.18	
03H	Transmission	1.39	
03K	Shaft Assemblies	0.75	
03N	Final Drives	2.49	
03Q	Integral Brakes and Steering	5.92	
04A	Electrical System	52.93	52.93
04B	Fire Exting. System	0.18	0.18
04D	Chassis Accessories	1.96	1.96
04E	Winch & Power Takeoff	0.10	
04H	Other	0.44	0.22
05B	Attachments & Appendages	0.00	
05E	Turret Elect.	4.33	4.33
05H	Other	0.25	0.13
06B	Sensors	0.00	
06D	Displays	0.01	0.01
06E	Sights and Scopes	33.19	33.19
06F	Computer	0.78	0.78
06H	Other	11.10	5.55
07A	Main Gun	12.21	
07C	Secondary Armament	0.78	
07D	Other	1.01	
11	NBC Equip.	0.24	0.24
12D	Furnishing and Equipment	1.77	1.77
13	Navigation	2.76	2.76
14	Comm.	14.64	14.64
17B	Other	0.08	0.04
18	Other	14.91	7.46
Total		**432.12**	**126.18**

OSMIS data is only available at this level of detail for O&S Class IX parts costs. Other OSMIS cost data is less detailed. Consequently, we will use this 29% factor for estimating the cost savings attributable to other operating costs. A similar analysis was conducted on the O&S costs for the M2 Bradley and it was found that Mode 1 ET exercises could be conducted for 36% of live training costs on the M2.

Force-On-Force Exercises

The baseline cost comparison begins with Force-on Force Exercises at Ft. Irwin and Ft. Hood. We contacted personnel at Ft. Irwin and found that in the average exercise, the attacking force travels 20 Km (12.5 miles) over a period of four hours. The attacking force would be conducting a Movement to Contact, Deliberate Attack or Hasty Attack per ARTEP 17-237-10 MTP. The other force would be conducting a Hasty or Prepared Defense and would travel one mile during the exercise. Table 2 contains an analysis of the cost of NTC exercises.

Table 2
Estimated Cost of Live Training Exercises
At Ft. Irwin

Vehicle	Cost Per Mile ($) O&S Class IX	Cost Per Mile ($) Petroleum, Oil, & Lubricants	Cost Per Mile ($) Intermediate Maintenance	Miles Driven Per Exercise	Number of Vehicles	Cost Per Exercise
Blue Forces						
Battalion Task Force Attacking						
M1A2	432.12	5.83	5.09	12.5	22	121,836
M2	56.75	0.88	80.74	12.5	22	38,052
Total						$159,888
Battalion Task Force Defending						
M1A2	432.12	5.83	5.09	1.0	22	9,747
M2	56.75	0.88	80.74	1.0	22	3,044
Total						$12,791
Red Forces						
Regiment Attacking						
M1A2	432.12	5.83	5.09	12.5	27	149,526
M2	56.75	0.88	80.74	12.5	90	155,666
Total						$305,192
Company Defending						
M1A2	432.12	5.83	5.09	1.0	3	1,329
M2	56.75	0.88	80.74	1.0	10	1,384
Total						$2,713

The Blue Force will generally consist of 22 M1A2s and 22 M2s. OSMIS data indicates that the O&S Class IX parts cost per mile would be $432 for M1A2s and $57 for M2s. OSMIS also indicates that Petroleum, Oil and Lubricant (POL) costs are $5.83/mile for the M1A2 and $0.88/mile for the M2. Intermediate Maintenance costs for the M1A2 and M2 are $5.09/mile and $80.74/mile respectively. Apparently, M2 parts can be repaired at Ft. Hood (Intermediate Maintenance) and M1A2 parts must be sent to the depot (O&S Class IX). Another expense of a live exercise is the Tactical Engagement Simulation System (TESS) equipment such as MILES/TWGSS/PGSS. Support costs for TESS equipment as well as the ET equipment are currently unknown. Since the ET equipment is next generation electronics and will be mounted inside the vehicle, ET support costs are certain to be lower than TESS equipment. We chose to take a conservative approach and assume these costs will be the same and left them out of the cost analysis.

Doctrine states that attackers should have a 3-1 numerical advantage over the defender to assure success. Consequently, in NTC exercises, Blue Battalion Task forces (44 vehicles) attack Red Motorized Rifle Companies (13 vehicles) and defend against Red Motorized Rifle Regiments (117 vehicles). Note in Table 2 that the total Blue Forces costs for attacking and defending exercises would be $160K and $13K respectively. To simulate a Motorized Rifle Regiment for an attack would require 27 M1A2s and 90 M2s. To simulate a Motorized Rifle Company for a defense would require three M1A2s and 10 M2s. Consequently, the cost of the simulated Red Forces would be $305K for a four hour attack exercise and $2.7K for a defense exercise.

The primary target for ET would be force-on-force exercises at Ft. Hood. We contacted resource allocation personnel at Ft. Hood and found that the attacking force in force-on-force exercises at the battalion level will travel 15-20 Km (11 miles). Table 3 contains the same information as Table 2 but the distance covered is changed to 11 miles for Ft. Hood exercises.

Table 3
Estimated Cost of
Live Training Exercises
At Ft.Hood

Vehicle	Cost Per Mile ($) O&S Class IX	Cost Per Mile ($) Petroleum, Oil, & Lubricants	Cost Per Mile ($) Intermediate Maintenance	Miles Driven Per Exercise	Number of Vehicles	Cost Per Exercise
Blue Forces						
Battalion Task Force Attacking						
M1A2	432.12	5.83	5.09	11.0	22	107,216
M2	56.75	0.88	80.74	11.0	22	33,486
Total						$140,701
Battalion Task Force Defending						
M1A2	432.12	5.83	5.09	1.0	22	9,747
M2	56.75	0.88	80.74	1.0	22	3,044
Total						$12,791
Red Forces						
Regiment Attacking						
M1A2	432.12	5.83	5.09	11.0	27	131,583
M2	56.75	0.88	80.74	11.0	90	136,986
Total						$268,569
Company Defending						
M1A2	432.12	5.83	5.09	1.0	3	1,329
M2	56.75	0.88	80.74	1.0	10	1,384
Total						$2,713

Table 4 indicates how much these same exercises would cost using ET technology. Since the ET-equipped M1A2 would be stationary, the O&S Class IX costs per simulated mile would be 29% of the moving vehicle costs per mile as indicated in Table 1. Since the tank will be stationary, the engine will not be operating, but he External Auxiliary Power Unit (EAPU) will be supplying power. The EAPU is too new to obtain data on the cost per hour of operation, so we are assuming 10% of the engine operating cost for now. Applying the 29% factor to M1A2 intermediate maintenance costs, we obtain an estimate of $1.48 per simulated mile using ET. The M2 does not have an EAPU, so ET fuel consumption is assumed to be the same as when moving. Applying the 36% factor to M2 intermediate maintenance costs, we obtain an estimate of $29.07 per simulated mile using ET technology. All of the other vehicles in the exercise will be virtual. Consequently, their cost per mile will be zero. As indicated earlier, operating costs for ET equipment is not currently available and will be added later. The estimated cost for 22 M1A2 tanks and 22 M2 Bradleys to conduct a four hour force-on-force virtual exercise would be $43,226 for an attack exercise and $3,929 for a defense exercise.

Overall Summary

Table 5 contains a summary of cost estimates for Red and Blue forces attacking and defending. Red forces may either use TESS equipment or be portrayed virtually using ET technology. Blue forces may use TESS equipment, or it may use ET technology while moving or while stationary.

Table 4
Estimated Cost of
Embedded Training Exercises
At Ft.Hood

Vehicle	Cost Per Mile ($) O&S Class IX	Cost Per Mile ($) Petroleum, Oil, & Lubricants	Cost Per Mile ($) Intermediate Maintenance	Miles Driven Per Exercise	Number of Vehicles	Cost Per Exercise
Blue Forces						
Battalion Task Force Attacking						
M1A2	126.18	0.58	1.48	11.0	22	31,034
M2	20.43	0.88	29.07	11.0	22	12,192
Total						$43,226
Battalion Task Force Defending						
M1A2	126.18	0.58	1.48	1.0	22	2,821
M2	20.43	0.88	29.07	1.0	22	1,108
Total						$3,929
Red Forces						
Regiment Attacking						
M1A2	0.00	0.00	0.00	11.0	27	0
M2	0.00	0.00	0.00	11.0	90	0
Total						0
Company Defending						
M1A2	0.00	0.00	0.00	1.0	3	0
M2	0.00	0.00	0.00	1.0	10	0
Total						0

TESS Equipment

The baseline case is both Blue and Red forces using TESS technology. When Blue forces are attacking, 22 Abrams and 22 Bradleys will travel 11 miles (Table 3) for a cost of $140,701. The Red forces will be defending and 3 Abrams and 10 Bradleys will travel 1 mile for a cost of $2,713. The total cost of a TESS exercise with Blue attacking will be $143,414. When Blue forces are defending, 22 Abrams and 22 Bradleys will travel 1 mile (Table 3) for a cost of $12,791. The Red forces will be attacking and 27 Abrams and 90 Bradleys will travel 11 miles for a cost of $268,569. The total cost of a TESS exercise with Blue defending will be $281,360. The total cost of one Blue Attacking and one Blue Defending engagement using TESS technology would be $425K.

ET Technology-Vehicle Moving

When using ET technology with the vehicles moving, the operating costs for the Blue forces vehicles will be the same as those using TESS equipment. The cost saving will come from virtual representation of the Red Forces. When Blue forces are attacking, 22 Abrams and 22 Bradleys will travel 11 miles (Table 3) for a cost of $140,701. The Red forces will be virtual for a cost of $0. When Blue forces are defending, 22 Abrams tanks and 22 Bradleys will travel 1 mile (Table 3) for a cost of $12,791. The Red forces will be virtual and cost $0. The total cost of one Blue Attacking and one Blue Defending engagement using ET technology with the vehicles moving would be $153,492.

ET Technology-Vehicle Stationary

When using ET technology with the vehicles stationary and partially powered up, the operating costs for the Blue forces Abrams tanks are depicted in Table 4. The cost savings will come from virtual representation of the Red Forces; as well as the lower operating costs of a partially-powered-up stationary vehicles. When Blue forces are attacking, 22 Abrams and 22 Bradleys will travel 11 **virtual** miles (Table 4) for a cost of $43,226. The Red forces will be virtual for a cost of $0. When Blue forces are defending, 22 Abrams and 22 Bradleys will travel one **virtual** mile (Table 4) for a cost of $3,929. The Red forces will be virtual and cost $0. The total cost of one Blue Attacking and one Blue

Table 5
Cost Effectiveness Comparison of
Embedded Training (ET) Technology and
Tactical Engagement Simulation System (TESS) Technology
In Home Station Attack & Defend Exercises

TESS Engagement				ET Moving Vehicle[1]				ET Stationary Vehicle[2]			
Blue Attacking[3]		Blue Defending[4]		Blue Attacking[5]		Blue Defending[6]		Blue Attacking[7]		Blue Defending[8]	
Red Costs	Blue Costs	Red Costs	Blue Costs	Red Costs	Blue Costs	Red Costs	Blue Costs	Red Costs	Blue Costs	Red Costs	Blue Costs
$2,713	$140,701	$268,569	$12,791	$0	$140,701	$0	$12,791	$0	$43,226	$0	$3,929
$143,414		$281,360		$140,701		$12,791		$43,226		$3,929	
$424,774				**$153,492**				**$47,155**			

Notes:
1. Vehicle Moving with Mixed Live/Virtual Targets on Live Terrain
2. Vehicle Stationary with Virtual Targets on Virtual Terrain
3. Live Blue Battalion Task Force Attacks Live Red Motorized Rifle Company
   22 Live Abrams & 22 Live Bradleys drive 11 miles to attack
   3 Live Abrams & 10 Live Bradleys drive 1 mile to defend
4. Live Red Motorized Rifle Regiment Attacks Live Blue Battalion Task Force
   22 Live Abrams & 22 Live Bradleys drive 1 mile to defend
   27 Live Abrams & 90 Live Bradleys drive 11 miles to attack
5. Live Blue Battalion Task Force Attacks Virtual Red Motorized Rifle Company
   22 Live Abrams & 22 Live Bradleys drive 11 miles to attack
   3 Virtual T-90s & 10 Virtual BMPs defend
6. Virtual Red Motorized Rifle Regiment Attacks Live Blue Battalion Task Force
   22 Live Abrams & 22 Live Bradleys drive 1 mile to defend
   27 Virtual T-90s & 90 Virtual BMPs attack
7. Live Blue Battalion Task Force Attacks Virtual Red Motorized Rifle Company
   22 Live Abrams & 22 Live Bradleys remain stationary and conduct virtual attack
   3 Virtual T-90s & 10 Virtual BMPs defend
8. Virtual Red Motorized Rifle Regiment Attacks Live Blue Battalion Task Force
   22 Live Abrams & 22 Live Bradleys remain stationary and conduct virtual defense
   27 Virtual T-90s & 90 Virtual BMPs attack

Defending engagement using ET technology with the vehicles stationary would be $47K.

Overall ET Technology Cost Savings

These costs are depicted graphically in Figure 1. In comparing the overall costs of the three simulation alternatives, it is apparent that ET with moving vehicles is roughly one third as expensive as TESS technology and ET with stationary vehicles is roughly one ninth as expensive.

Firing Range Savings

We visited Ft. Hood to obtain tank gunnery range operating costs. Range management personnel provided the following cost information:

- $5M/yr in civilian pay
- 50 soldiers/yr. with an average pay grade of E5 (~$2M/yr)
- $2M/yr contractor costs to operate two ranges
- $2.2M/yr on targets and supplies
- $1M/yr on range maintenance
- $4M/yr on range modernization

This adds up to about $16M per year to operate and maintain the gunnery ranges at Ft. Hood. If ET technology could be used to replace some of the initial qualification rounds and to greatly reduce the need for physical targets during qualification rounds, it would appear that ET could save one fourth of the $16M/yr required to operate and maintain the range.

While gathering the cost data above, we were told that the current system has the following shortcomings.

- Long range shots in accordance with doctrine cannot be practiced on the current ranges because the range is not deep enough.
- The Commander's Independent Thermal Viewer cannot currently be used effectively due to the limited space in the ranges.
- Target handoff using digital systems cannot be practiced using the current system.

Using ET technology, these capabilities could be added at minimal cost. Ft. Hood is currently investigating means of developing a Multipurpose Digital Range that will allow crews to exercise digitization of the battlefield type capabilities. ET technology would make this range enhancement affordable.

Finally, tank crews are required to qualify on miniature target ranges before they are allowed to advance to the full sized range. It would appear that the ET technology could completely eliminate the need for this capability. No data on the cost of these ranges is available at this time.

Payback Period

As stated earlier, the STRICOM Embedded Simulation team anticipates that the ET technology being developed on this program will be used to expand training opportunities as opposed to being used to justify the reduction of OPTEMPO budgets. However, all cost effectiveness analyses must present a projected payback period if the technology is implemented. This payback analysis is presented below.

ET Acquisition Costs

The ET technology being developed on this project will make heavy use of COTS computers and image generators. The video game industry is driving this technology such that the performance/cost ratio is improving exponentially. The common understanding of Moore's Law is that each eighteen month design cycle doubles computer performance while the price remains the same. The ET technology being developed on this project is targeted for implementation in 2003, which is two design cycles away. This will lead to a four-fold increase in computer power at today's prices. The target price for the ET technology discussed in this paper is $50K per vehicle. Consequently, it will cost $2.2M to implement ET technology on a platoon of Abrams and Bradleys (44 vehicles).

Calculated Payback Period

Figure 2 depicts the projected payback period for the implementation of ET technologies. The curves on the graph indicate the cumulative cost of training exercises for a platoon of Abrams and Bradleys. For TESS technology, the starting point is zero because the system is operational and no up-front investment is required. The curve represents the cumulative cost of each attack-defend pair of four hour exercises at a cost of $424,774 apiece. For ET technology with the vehicle moving, the starting point is $2.2M initial cost plus a cumulative cost of $153,492 per attack-defend pair of exercises. The ET Technology with the vehicle stationary also starts at $2.2M and accumulates at a rate of $47,155 per exercise pair. Note that the payback period is six exercise pairs for ET technology with the vehicle stationary and nine exercise pairs with ET technology with the vehicle moving. These very short payback periods indicate a very good investment on the part of the U.S. Army.

Figure 1
Exercise Cost By Technology

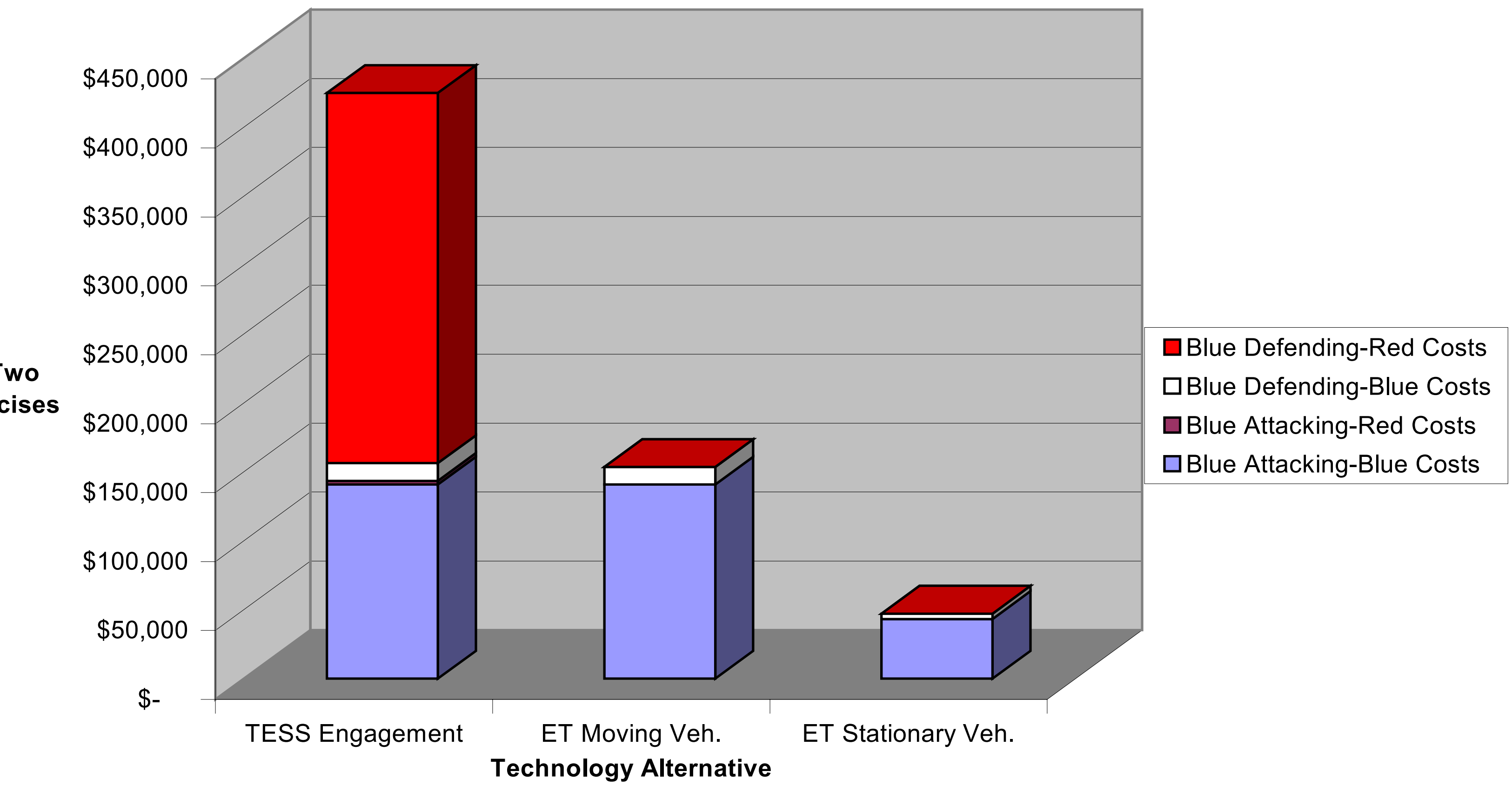
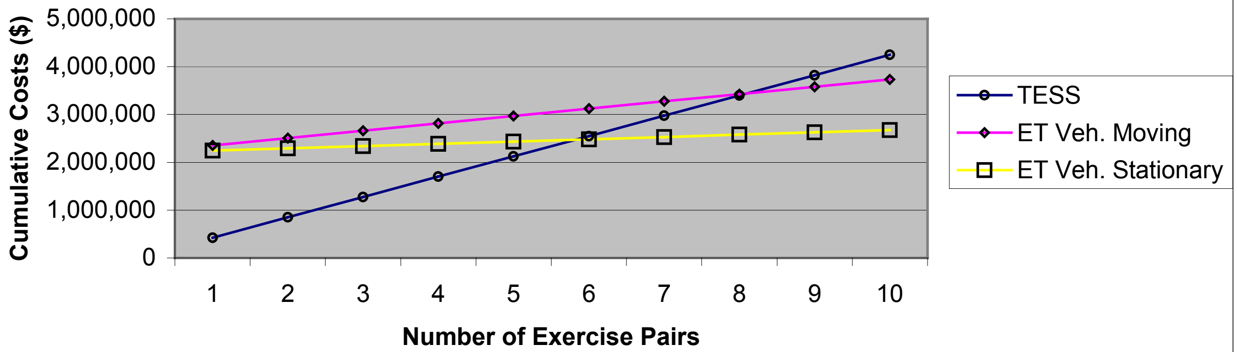


Figure 2
Payback Period for ET



Other Considerations

Currently Untrainable Tasks

Historically, stand alone training simulations have been especially valuable in training tasks that are essentially untrainable in live vehicles due to safety concerns or range limitations. As indicated above, long range shots and digital target handoff cannot now be done at home station ranges. Training other tasks may be prohibitively expensive (such as Take Active and Passive Air Defense Measures) due to the expense and availability of a cooperating air vehicle. ET technology will extend this ability to train untrainable tasks from stand-alone simulators into live vehicle.

More Efficient Use of Time

[Swinsick 1995] documented the cost and time savings associated with the use of manned simulation in Force Development Test and Experimentation (FDT&E) of the Longbow Apache. This document indicated that simulated exercises can be conducted in one-third the time of live exercises, primarily because simulated exercises do not include the time for Movement to IP and Return to IP. This three-to-one reduction in time to complete an exercise would be on top of the three and nine-to-one reduction in cost per hour/mile, resulting in an initial estimate of an 9/1 to 27/1 reduction in training costs attributable to ET.

Training Before and After Live Training Budget Expended

As indicated above, the authors recommend that this ET technology be used to provide initial training on vehicle operation and maneuver tactics before conducting live exercises. This initial training will allow the live exercises to be more productive and address more advanced tasks than is now possible. Once the OPTEMPO budget is expended, we recommend that ET technologies be used to continue training that cannot now be conducted on the actual vehicle.

Conclusions

In comparing the costs of ET technology to the cost of current TESS technology, we have found that ET technology can lead to three-to-one reduction in exercise costs with the vehicle moving and a nine-to-one reduction in cost with the vehicle stationary. These calculations are based on historical OPTEMPO costs that are detailed enough to allow the calculation of ET exercise costs in which some of the vehicle components are active and others are idle. It is hoped that this potential for dramatic reductions in home station exercise costs will lead to increased training opportunities as opposed to reduced OPTEMPO budgets.

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