

# ADVANCED DISTRIBUTED SIMULATIONS EFFICIENCIES & TRADEOFFS DVTE, DMT & BFTT EXPERIENCES

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## ABSTRACT

“Kill More, Die Less!” was coined by an active duty F-16 Pilot about his descriptive thoughts on the Distributed Mission Training (DMT) System. Reactions from Marines utilizing the Deployed Virtual Training Environment (DVTE) similarly expressed such positive enthusiastic comments and perceptions. The potential benefits of such Advanced Distributed Simulation (ADS) systems such as DMT, DVTE and Battle Force Tactical Training (BFTT) point the way ahead for more effective training of combat teams. The aims & opportunities of this publication are to:

- 1) Identify and codify advantages & costs/benefits tradeoffs of such ADS systems intuitively and graphically via the widely utilized “Miller’s Curves” (Miller 1953);
- 2) Outline DVTE innovation successes of evolving interoperable federates into a merged training federation via “common shared components” with associated lessons learned;
- 3) Posit an innovative “common shared components” fusion training evolutions of DVTE, DMT and BFTT;

Specifically, a framework utilizing Miller’s Curves constructs are presented to illustrate graphically the unique attributes of such ADS systems costs/benefits tradeoffs. These Miller’s Curves constructs are then discussed from the multiple perspectives of DVTE, DMT, and BFTT ADS Systems. Rather than argue the plethora of merits and disadvantages between fidelity and basing options, the authors posit the best course may be to fuse the three ADS systems and perform further training research as to costs/benefits tradeoffs to the warfighters. Multiple levels of benefits may result from merging the lower-cost, lower-fidelity deployed DVTE system with the higher-cost, higher-fidelity DMT and BFTT systems so as to provide for the full spectrum of ADS training requirements.

The initial DVTE successes associated with evolving new ADS training features are presented including the implementation of several innovative “common shared components” concepts. Additionally, several of the “common shared components” concepts are discussed from the context of providing startling new directions which in some cases mitigate and eliminate long standing problems that have plagued interoperable ADS systems since their inception. Of note, the scientific findings directly include the warfighters themselves determining best utilization and evolution of DVTE features and operation via User Scrutiny Events (USEs).

Further, current efforts to utilize selected “common shared components” of DVTE with DMT are presented with an illustrative example based upon planned replication of the highly successful DMT AWAC/pilots Team training with DVTE Forward Air Controller/Pilots Team training. Future research directions are outlined including current planning for merging DVTE with BFTT for additional mission rehearsal capacity under a program designated NexWars.

## AUTHOR’S BIOGRAPHIES

**Dr. Michael Page Bailey** graduated from the University of North Carolina at Chapel Hill with a Ph.D. in Operations Research in 1988, and in 1994 was promoted to Tenured Professor of Operations Research at the Naval Postgraduate School in Monterey, California. At NPS, Dr. Bailey was an award-winning teacher and widely-published researcher. In 1995, he sabbaticaled at the Office of the Chief of Naval Operations, Assessments Division, OPNAV-N81 as a visiting scholar and served as operations analyst in support of the Quadrennial Defense Review until 1997, after which he joined the Marine Corps as Principal Analyst, Modeling and Simulation. In December 1999, he joined the Marine Corps’ Training and Education Command as Technical Director. In December 2000, the Marine Corps formed the Training and Education Technology Division, with Dr. Bailey as its head. Technology Division is responsible for requirements, policies, and sponsorship of all technology applicable to Marine Corps professional military education, individual training, unit training, exercises, and ranges. These technologies include interactive multimedia distance-learning, weapon system and crew training simulators, simulation, interactive gaming, instrumentation, and classroom technology.

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## INTRODUCTION

“Kill More, Die Less!” was coined by an active duty F-16 Pilot about his descriptive thoughts on the Distributed Mission Training (DMT) System after just completing a week long Flight Lead Upgrade Training opportunity at AFRL (Crane 2000). Similar enthusiastic reactions have been recorded of Marines utilizing the Deployed Virtual Training Environment (DVTE). The Marines have expressed such positive perceptions and comments in answering the scientific surveys and interviews associated with the DVTE User Scrutiny Events (Zeswitz, Nolan 2002). More importantly the Marine actions, with team leaders and fire-team members, yelling and physically urging team mates in critical simulated battles speaks louder than mere words as to the Marines enthusiasm and involvement in DVTE events. The documented popularity with warfighters and potential benefits of such Advanced Distributed Simulation (ADS) systems such as DVTE, DMT and Battle Force Tactical Training (BFTT) point the way ahead for more effective training of combat teams. The realism of the these ADS systems is illustrated below ( See Figure #1 actual screen captures from DMT & DVTE systems)

Figure #1 Two screen capture images in order are: Top from AFRL’s DMT Testbed Viper 5 which depicts a Flight of F-16s over Aviano Italy; Bottom from USMC’s DVTE which depicts a combined arms battle at 29 Palms. These images provide a context for the realism that the current generation of ADS systems provide participants. (Of interest the images were generated on a range of hardware solutions ranging from dedicated 8-channel state-of-the-art dual CPU 60Hz 9X PC-IG Arrays for DMT type systems to single CPU Dell Laptops utilized in DVTE).

The ADS systems team training objectives focus centers on providing realistic simulated combat environments where teams learn, refresh, or sustain critical team skills for combat readiness. Figure #2 below provides images of the ADS systems in use by U.S. teams.



Figure #1 DMT & DVTE Screen Captures



Figure #2 DMT and DVTE Teams in Action

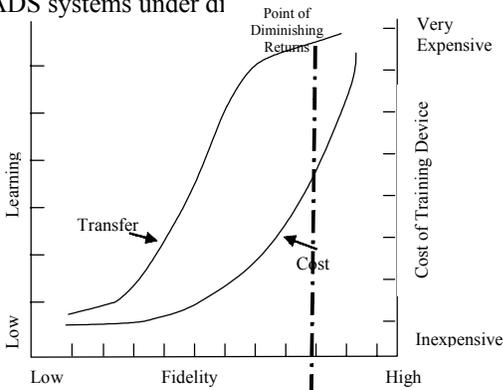
DMT, DVTE, and BFTT ADS systems provide entirely new levels of team training to warfighters (Crane 1999, 2000, Bennett 2000, Guckenberger et. al. 2000, 2001, 2002, Zeswitz 2002, Kassel 2000).

Separately successful, separately planned, separately evolving, yet interoperable in a manner that holds the promise of potential synergy for even greater successes and greater benefits to the warfighters.

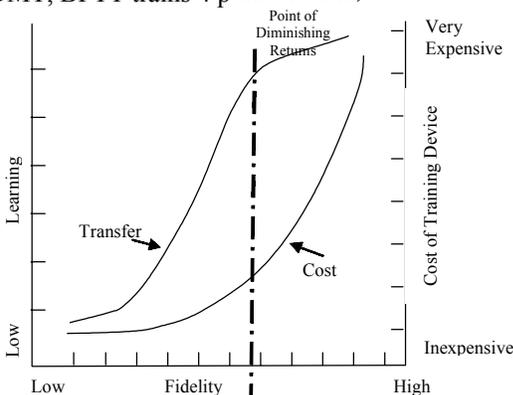
### ADVANCED DISTRIBUTED SIMULATIONS SYNERGY

#### DMT, BFTT, and DVTE “Miller Curves”

1) The aims and opportunities of this publication are to identify and codify advantages, cost/benefits tradeoffs of such ADS systems intuitively and graphically via the widely utilized “Miller’s Curves” (Miller 1953). That is, utilize the Miller’s Curves constructs to conceptualize and visualize the advantages, costs/benefits tradeoffs for DMT, BFTT, and DVTE contexts. These high level abstractions are meant to illuminate ADS systems similarities and differences between the DMT/BFTT high-fidelity, higher-costs systems with the DVTE type lower-fidelity, lower-costs systems. Figure#3 illustrates notional representations of Miller’s Curves for the current versions of the three ADS systems under di



DMT, BFTT trains 4 pilots or CIC



DVTE trains 32 Marines simultaneously

#### Figure #3 Notional Miller’s Curves Constructs of DMT, BFTT & DVTE

Figure#3 specifically, depicts the framework for utilizing Miller Curves constructs by illustrating graphical the unique attributes of ADS systems

costs/benefits tradeoffs. The respective curves illustrate the notional differences in fidelity, transfer of training and costs from multiple perspectives of DVTE, DMT, and BFTT ADS Systems. Note the similarity in the DMT and BFTT systems which provide high-fidelity, high-transfer of training, at higher costs by design. Similarly note that the evolving DVTE system aims at providing medium fidelity, similar transfer of training, at much lower costs by design. Basically DMT and BFTT currently provide capstone team training where the highest levels of fidelity and are maintained at the technological state-of-the-art at relatively high training expense, but still much less expensively, and without the safety/security constraints of similar Live Exercises. Decision making skills and team training have greatly benefited from these systems (Crane 1999, 2000, Bennett 2001, Kassel 2000). Both DMT and BFTT plan to bring the training to the teams rather than the teams to the training by building multiple DMT Mission Training Center on airbases and BFTT with there “At-Sea” initiatives to allow BFTT utilization in deployed fashion. Uniquely, DVTE primary delivery mechanism has always been the deployed option from its initial inception. This confluence of training research efforts towards deployed training and just-in-time mission rehearsal suggests that the three ADS systems might benefit from sharing lessons learned, reuse/sharing of HLA/DIS components and potentially sharing of team training cognitive decision making support aids for actual operation use.

Ignoring the plethora of differences and concentrating on the commonality, provides insight that the interoperating or merging of such ADS systems may have merit is training a full range of team training requirements at advantageous cost/benefit ratios. Further, beyond the scope of this paper, similar joint mission rehearsal and operational employment of such merged ADS systems may have merit.

Not shown in the Miller Curve constructs are the effects of basing options. Currently DVTE primary utilization will be deployed with similar efforts being undertaken with the “Scalable DMT” and the “BFTT Underway” efforts. Rather than argue the plethora of merits and disadvantages between fidelity and basing options the authors posit the best course may be to fuse the three ADS systems and perform further training research to advantages/tradeoffs to the warfighters. Multiple levels of benefits may result from merging the lower-cost, lower-fidelity deployed DVTE system with the higher-cost, higher-fidelity DMT and BFTT systems to provide the full spectrum of ADS training requirements. The lowest level of benefits of the merge could be analogical to the part-task training concepts, where DVTE laptops could be utilized to “part-task” train some of the team training skills to optimize warfighters

time on the DMT and BFTT systems and Live exercises. Potentially training research may demonstrate that DVTE laptop team training can reduce the fall off skills and readiness or otherwise augment team training between scheduled DMT, BFTT and Live exercise events.

The potential benefits of merging ADS systems are many and varied; many have shared such a promising vision for the future. What has been lacking are realistic methods to achieve this vision. Early attempts by others to perform merging of ADS systems have been plagued by database correlation issues, visual and sensor discrepancies, temporal update differences, long haul physics based difficulties since the first days of SimNet and DIS. The following sections outline innovative successes within DVTE that may have merit in mitigating and in some cases eliminating long standing ADS interoperability problems.

### **DVTE Innovative “Common Shared Components” Successes**

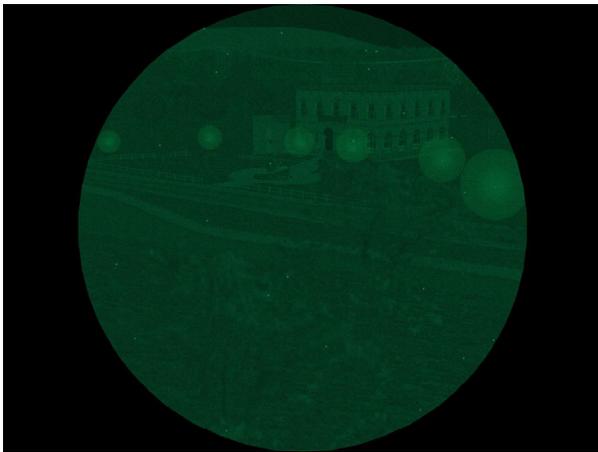
2) Outline DVTE innovation successes of evolving interoperable federates into a merged training federation via “common shared components” with associated lessons learned. Uniquely, DVTE can be considered a success template for progressing interoperable simulators into a fully integrated training system. Specifically, DVTE ‘intra-federation’ lessons learned may be extrapolated to ‘extra-federation’ guidelines for merging additional HLA Federates, DIS nodes (e.g., or additional ADS systems as in Section #3 below).

DVTE began as a collection of disparate independent systems that were modified to interoperate at the HLA level utilizing an early version of the MAGTF FOM. Virtual Simulators: Raydon LAVs; FATS Forward Observer Trainer; NAVAIR MFS Helicopters; Constructive Simulations of JSAF and the Naval Visualization Program (NVP) all interoperated to produce a successful Marine User Scrutiny Event#1 in December 2001 (Zesititz 2002). Additionally, a separate Infantry skills collection of simulators were developed along with an Online Video game. These two networks were designated the CAN for Combined Arms Network HLA Federation and the ITK for Infantry Toolkit on-line game based with decision skills sims. The Marine USE #1 provided insights and guidance as to strengths, benefits, and suggested modifications to evolve DVTE. The Marine, SMEs, and Training Experts inputs were all captured into a USE#2 Requirements Matrix to guide said evolution. A major achievement of USE#1 that was widely praised were the DVTE developers porting their existing

products to federates that run on COTS Dell Laptops with GeForce 2 GO graphics (with one exception). Although DVTE was interoperable and a success as designed from a requirements generation perspective, it was clear from the Matrix that from a technical perspective DVTE suffered the traditional problems of disparate interoperating systems. Specifically, a preponderance of the Matrix improvement inputs pointed out differences between the five different visual systems (e.g. database correlation errors; differences in resolution, color depth; special effects differences between systems; etc...), usability suggestions for improving simulation control; communication improvements, and additional support and automation aids for the instructor/facilitators.

To address the Matrix the DVTE Integrated Product Development teams collectively decided to re-architect the DVTE federation in a bold fashion. The design solution adopted was to develop common components that eliminated the disparities between DVTE federates. Uniquely rather than just be interoperable, DVTE was to be evolved into a merged system of systems. Specifically, for USE#2 each federation became merged systems that utilized common DVTE components. The major changes were:

**Common Scene Manager** -- The five different USE#1 scene managers were replaced with a selected Common Scene Manager (CSM) for USE#2. Rationale was correlation and visual differences would all be eliminated with this single bold move. Additionally, the cost savings for the lifecycle of the DVTE program was a driving factor in the decision especially in light of the DVTE mission rehearsal requirements. Rather than five different versions of each database being built as USE#1 required for each battlefield the CSM required only one open standard database in USE#2. Further, DVTE specific features of detail texture, advanced special effects, 3D models, cultural features and terrains were developed, implemented and tested once in the CSM rather than five different versions between and betwixt. Figure #4 below, shows the Visual, IR and NVG screen captures from the DVTE Common Scene Manager (i.e., AAcuity Image Generation Software).



**Figure #4 Common Scene Manager Screen Captures of Visual, IR and NVG Exemplars**

(1600x1200 resolution of 29 Palms and the TMZ MOUT Databases)

Figure #4 illustrates the level of high fidelity of Photo-Realistic, Geo-Specific Visual/Sensor DVTE terrains

and 3D models. Of note is the current DVTE Dell Laptops with GeForce 4 GO graphics allows any laptop to be configured to be any DVTE role. Contrary to the nominal thoughts that the laptop hardware selection would limit graphics to lower fidelity the newest generation of NVIDIA graphics in laptops alters the paradigm and state-of-the-art graphics are provided to the DVTE Marines to aid in the suspension of disbelief and increase Marine involvement. A related finding was the automation of the current terrain generation tools (Terrex in this case) have progress to where it is more efficient cost and schedule to produce state-of-the-art visual/sensor databases with correlated CTDB for the JSAF constructive simulations than to try to port and update sparse legacy databases. Also of interest the source imagery for 29 Palms terrain was 0.5 meter with a resultant database that realistically recreates the USMC live fire terrain.

**Common Sim-Control** – The different Federates were started manually for USE#1, and evolved for USE#2 to allow a single PC Laptop start and stop the entire CAN Federation or Infantry Toolkit (ITK) On-Line Game. The USE#2 implementation utilized MARCI machine level control from central IOS nodes to start/stop and freeze/ resume\* the DVTE Combined Arms Network HLA Federation and/or the ITK. Planned USE#3 evolutions will include further extensions to the MAGTF FOM to work in concert with the MARCI machine level control to advanced HLA federate controls including teleport, replace and potentially roll-back, redo features.



**Figure #5 DVTE Sim-Control Graphic User Interface**

The easy to use Marine GUI shown in Figure#5 illustrates the simple user friendly design that guides the interface design for DVTE and by extension potentially to other ADS. The Sim-Control module allows selection of CAN or ITK and then launches the entire network of laptops for the selected scenario based



blue and the first-fire tags. This automated tagging compliments the manual tagging the instructors can add at their discretion. The concept and associated HLA software constructs provide an entirely new methodology for automating detection and recording of learning events. For USE#3 the Common AARS will utilize mission and terrain reasoning services from the mission functions module of the Common Scene Manager to perform additional advanced reasoning.

### **“Common Shared Components” Fusion Training Evolution of DVTE, DMT and BFTT**

3) Posit an innovative “common shared components” fusion training evolution of DVTE, DMT and BFTT (Battle Force Tactical Training). As was previously suggested merging the unique attributes of all three ADS systems presented could produce multiple levels of benefits and advantageous tradeoffs. That is, the combining of the lower-cost lower fidelity deployed DVTE system with the higher cost higher fidelity DMT and BFTT systems to provide the full spectrum of ADS training requirements. Again, rather than argue the merits and disadvantages fidelity and basing options the authors suggest the best course may be to fuse the three ADS systems and research the advantages to the warfighters with the warfighters themselves determining best utilization via User Scrutiny Events (USE).

The author’s initial first level integration testing of DVTE with DMT was a success by utilizing the same “Common Scene Manager” Software components on the AFRL DMT Testbed Viper 5 M2DART Visuals with a virtual aircraft simulation utilizing the DVTE 29 Palms database and 3D models at 60Hz with DVTE laptops providing FAC views of the same database and 3D models. This first effort was DIS based but further integration is planned with DIS/HLA Gateway support for adding additional “common shared components” between the two systems. The authors suggest that the use of such “common scene manager components” is an entirely new paradigm which greatly reduces in and in some cases eliminates the extensive and costly efforts to correlate multiple databases and the huge expenses associated with maintain said multiple correlated databases. Detractors of the “common shared scene manager” approach would have readers believe that substituting and replacing the scene manager is an impossible expensive task. The authors point out that the five DVTE developers with five mature standalone products that were not architected originally for any such common shared common scene manager approach were able to convert to the DVTE CSM in less than 6 months. Further, the CSM conversion provided features such as detail texture, particle based special

effects, advanced lighting, weather effects, IR and NVG to products that had hither to not had. Similarly, the AFRL, MFS and the authors support the Visual Interface Unit (VIU) initiatives where the sim-host to IG interface is abstracted to a standard interface (Guckenberger 19\*\*, Guckenberger 19\*\*, Call 19\*\* ). Finally, the CSM approach has direct utility for mission rehearsal optimizations and potentially will provide utility in actual operational contexts as simulation evolves into operational contexts. For example the CSM could be common to mission planning tools, the training ADS systems, the deployed just-in-time mission rehearsal ADS systems and in the operational Virtual Reality Helmet Mounted Displays as Synthetic Vision Overlays and Augmented Reality enhancements (Guckenberger 2002).

### **SUMMARY AND FUTURE RESEARCH DIRECTION**

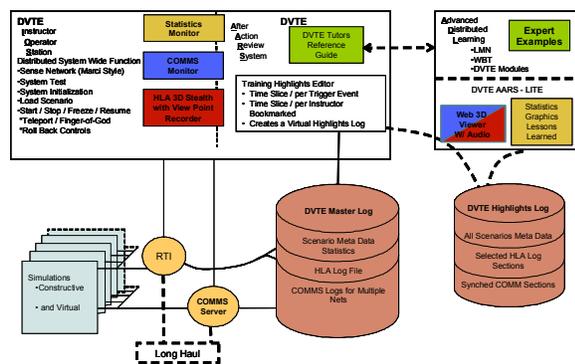
To clarify the authors are not suggesting replacement of high fidelity ADS systems, rather the suggested course of actions are innovative augmentation concepts. Specifically, the DMT and BFTT ADS systems which have higher-costs and lower numbers of fielded advanced distributed simulations can be augmented with lower-cost more numerous COTS deployed distributed simulations. The analogy is an evolution of the part-task trainer concept into advanced distributed simulations with Laptop or Web based ADS part-task team training warfighters in preparation for capstone training on DMT, BFTT and or Live Exercises. This augmentation concept exploits ADS similarities and successes that come from critical soft skills developments as the warfighters learn to work as a team better, with better communication, better planning, better what if’ing, better execution and more effective debriefing with lessons learned shared, applied rapidly and effectively. DMT and BFTT provide the highest fidelity training today, however potentially some selected soft skills may be more efficiently “pre-taught” and “refreshed” on something like DVTE. At the very least low-cost pre-DMT, or pre-BFTT training on DVTE laptops may ensure more effective utilization of these high value training resources. Realistically, post-DMT and psot-BFTT training on DVTE may delay decay of critical skills and readiness until the next scheduled high fidelity ADS or Live Exercise.

**DMT + DVTE** -- The greatest benefits may be in simultaneous utilization of ADS systems. For example, DMT successes to date have been primarily focused on the air-to-air training tasks. The rapid repeatable of DMT training events has demonstrated huge performance gains in AWACS/Pilot teams.

However, in recent conflicts the USAF/USN has quickly swept the enemies from the skies. These air superiority victories are followed by months of effective ground attacks. The authors hope to perform further DVTE/DMT training research that replicates the same dramatic performance increases in DVTE FAC/Pilot teams as has already been demonstrated in DMT AWAWS/Pilot Teams (Crane 1999,2000a,2000b, Bennett 2001). Additional levels of DVTE and DMT training research and testing are planned with the eventual goal being simultaneous utilization of AFRL DMT Testbed, NAVAIR MFS Simulators, and DVTE globally.

**BFTT + DVTE** -- The authors, DVTE developer and PMS430 are also currently planning an integration of DVTE with BFTT with emphasis on USN and USMC mission rehearsal within a 24 hour notice of operations order goal for USE#3 under the NexWars project.

**ADS-Architectures** -- The authors wish to be perfectly clear we are strongly suggesting benefits by augmentation not replacement of DMT, BFTT and Live Training Exercises. The overall architecture plan for DVTE includes development of web based components to even further extend the utilization of “learning events” (See Figure #8)



**Figure #8 DVTE LifeCycle Learning Diagram**

Figure #8 depicts the high-level architectural block diagram of DVTE. The novel sharing of resources between the IOS and AARS/Debrief stations is efficient from a training and technological perspectives, especially in light of the deployed requirements (i.e. dual use of limited computer resources). The web DVTE-Lite module is still in development; however the highest risk element an Internet Browser version of the CSM has already been successfully tested. The vision for web DVTE-Lite module is to allow lessons learned and case studies to be widely shared, rapidly distributed and directly included into academics as relevant illustrative exemplars. Finally evolutions and

variations of this architecture may have new levels of benefits when utilized for operational planning, briefing and debriefing.

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