Tactical Decision Kits for Infantry Training

Christopher Young, Richard Schaffer
Lockheed Martin Rotary & Mission Systems
Burlington, MA
Christopher.A.Young@lmco.com, Richard.L.Schaffer@lmco.com

Michael Longtin
Lockheed Martin Rotary & Mission Systems
Orlando, FL
Michael.Longtin@lmco.com

Brian Stensrud, PhD
Soar Technologies,
Orlando, FL
stensrud@soartech.com

LtCol Marcus J. Mainz
2d Marine Division
United States Marine Corps
Camp Lejeune, NC
Marcus.Mainz@usmc.mil

ABSTRACT

The natural environment for infantry training is in the field where unit leaders learn the decisions made on a map may be different from those operating in the battlefield environment. When a unit is in garrison, the commander has a difficult challenge effectively promoting those same decision-making skills throughout the ranks. To better utilize his Marines' time between field exercises, one battalion commander envisioned a solution that would foster tactics training across all echelons. The resulting Tactical Decision Kit (TDK) married the work being done by the Office of Naval Research to address small-unit decision-maker training and extant fielded simulators to replicate the real-world experience and form that connection between 2D tactical planning and 3D execution, resulting in better decision-makers.

The TDK supports a full spectrum of training, including tactical decision games, sand table exercises, competitive simulated engagements and field exercises across all phases of the mission from planning to execution to after-action review. Technologies employed include web-enabled collaborative technologies, HoloLens mixed-reality, low-cost drones and photogrammetric terrain models, streaming media, distributed simulation, adaptive training and after-action review capture and playback. The experimental battalion, 2nd battalion 6th Marines (2/6), experienced increased performance in tactical thinking and communications using competitive simulated engagements, resulting in shorter planning cycles and increased efficacy of after-action reviews in field exercises. These gains were attained through ready access to data and use of visualization tools. This led to the decision by the Assistant Commandant of the Marine Corps to field the TDKs as an experimental platform to all infantry units with the latitude for battalion commanders to develop a tactical training path for their Marines.

This paper will discuss the operational concepts, the technologies and training approaches employed, as well as analysis of data collected both during the initial trials and after fielding the kits across the Marine Corps.

ABOUT THE AUTHORS

Christopher Young is a staff software engineer at Lockheed Martin Rotary and Mission Systems (RMS). and has been the lead developer and project engineer on several US Marine Corps and Office of Naval Research programs for Lockheed Martin's Advanced Simulation Center. Since 2014, Chris has been the lead developer of the Interactive Tactical Decision Games (ITDG) application, a major component of the Tactical Decision Kit. Mr. Young holds a Bachelor of Science degree in Aerospace Engineering from Boston University.

Michael Longtin is a senior staff software engineer at Lockheed Martin Rotary and Mission Systems (RMS). Michael has been working in the field of augmented reality, developing a terrain database generation system that creates terrain databases. Michael has also developed a mixed-reality sand table application for the Marines, an application that allows trainees to visualize three-dimensional terrain models for scenario creation and mission rehearsal. Mr. Longtin holds a Master of Science degree in Electrical Engineering from the University of Maine.

LtCol Marcus J. Mainz is serving as the 2d Marine Division Future Operations Officer. He is an infantry officer who has commanded from the Platoon to Battalion level. He has served as an educator in the Marine Corps at The Basic

School, Infantry Officers Course and Expeditionary Warfare School. He was also selected to attend the School of Advanced Warfighting and earned a Master's Degree in Operational Studies.

Richard Schaffer is a Lockheed Martin Fellow and Principal Investigator at Lockheed Martin Rotary and Mission Systems (RMS). He leads the Human Immersive Simulation Lab at RMS's Advanced Simulation Centers. Richard received his S.B. degree from the Massachusetts Institute of Technology and has over 34 years of experience in modeling and simulation research and development. His areas of research have included distributed simulation, environment modeling, immersive simulation and augmented reality. In 2010 he received the NTSA's lifetime achievement award.

Dr Brian S. Stensrud, PhD is a senior scientist at Soar Technology, a small business with offices in Orlando, FL and Ann Arbor MI that focuses on the research, development, and integration of artificial intelligence software for DoD applications such as training systems, autonomous platforms, and cybersecurity applications. On staff since 2003, Brian has served or is currently serving as Principal Investigator on over $30M of research and development contracts related to the field and has additionally served in a technical lead role in the development of several AI solutions and toolsets. Dr. Stensrud received a Ph.D. in Computer Engineering from the University of Central Florida in 2005, specializing in neural networks for tactical behavior learning, and also holds bachelor's degrees in Electrical Engineering and Mathematics from the University of Florida.

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INTRODUCTION

The Tactical Decision Kit (TDK) was created on the premise that technology could be brought to infantry units to increase tactical sets and reps, analogous to physical training (PT), while in-garrison between field exercises. LtCol Marcus Mainz, commander of 2nd Battalion 6th Marines (V26), previously had exposure during his time at Marine Corps University to many of the training applications and simulations available but underutilized by operational units. Additionally, applications under development for the Office of Naval Research (ONR) demonstrated at the Pentagon also caught LtCol Mainz's attention. He saw an opportunity to bring some of these technologies to V26 as an experimental platform for increasing training and evaluating tactical proficiency within the unit between field exercises. Over the course of about a year, the unit explored the possible uses of the technology, driving the use cases and innovation of ONR's applications, resulting in a system that was proliferated across the Marine Corps.

Tactical Decision Room Concept

V26 developed the concept of a Tactical Decision Room in 2016. As an infantry unit spends only 30% of its time training in the field, (Jontz, 2016) V26 evaluated candidate training technologies with a goal to maximize training efficiency during the remaining 70% of the unit's time in garrison, so that "in the same way as we exercise our bodies in PT, we need to exercise our minds." The Tactical Decision Room allowed members of each company to take advantage of the downtime between tasks to create and fight virtual missions to practice and enhance their tactical decision-making skills, learning which tactics were most effective for a given mission. The convenience of the Tactical Decision Rooms precluded the need to schedule time and resources at schoolhouses and battle sim centers and opened tactical decision-making training up to a wider audience within the battalion. Training resources that previously were mostly available to officers and senior NCOs now could be made available to more junior ranks (E1-E3) and junior NCOs (E4-E6).

V26 started with elements of the Deployable Virtual Training Environment (DVTE), a Marine Corps program fielded since 2008, comprised of a suite of laptops and software that includes the first-person simulation, Virtual BattleSpace (VBS), tactical simulation games such as Close Combat Marines (CCM), and combined arms simulations such as the Combined Arms Network (CAN). These systems mostly focused on team training scenarios. In addition, the Office of Naval Research was in the process of developing a suite of training tools as part of the Accelerating the Development of Small Unit Decision-Makers (ADSUDM) program. These included terrain creation tools, an application for creating and hosting Interactive Tactical Decision Games (I-TDGs), a Microsoft-HoloLens mixed reality SandTable application and applications for training assessment and after-action reviews. As the ADSUDM applications were still in development, V26 became the experimental battalion driving the use cases and requirements for the program.

These components offer a compromise between fidelity and time investment as shown in Figure 1. At the lowest end of the fidelity and time spectrum sit traditional Tactical Decision Games (a basic paper-and-pencil scenario with rudimentary graphics, initial dispositions and mission requirements used to develop a basic understanding of mission-type orders) and sandtable exercises (a more 3D representation of a TDG utilizing sand, rocks, mud and other available materials to construct and visualize a physical model of the terrain). At the high end are war games and force-on-force field exercises, but these take a large commitment of time and resources to plan, execute and analyze. The tactical decision room sits in the mid-range of fidelity with a 1-4-hour commitment for each exercise, a manageable period of time for an infantry unit while in garrison.

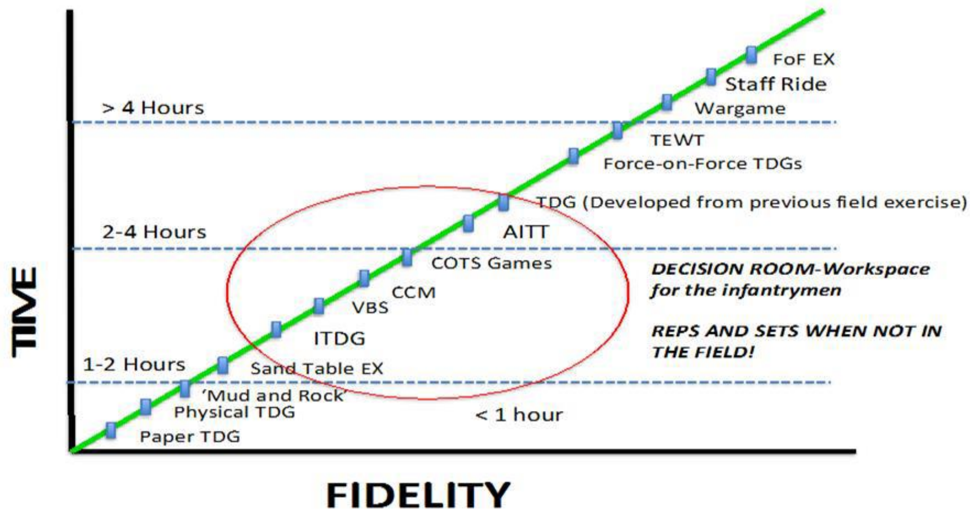

Figure 1. Decision Room Technologies Within the Tactical Training Spectrum

Tactical Decision Room Components

Synthetic Environment Terrain (SET) Tool: a terrain generation application supporting raster-based and photogrammetric mesh-based data sources to create terrains and map sets compatible with the applications of the tactical decision kit.

Interactive Tactical Decision Games (ITDG): an application employing a web-based framework for collaborative tactical decision game (TDG) scenarios using Mil-Std 2525C symbology, tactical graphics, drawing overlays, multimedia elements and scoring templates for conducting decision-making classes. The application was not designed to supplant the teaching methods currently used in TDG classes, but rather to enhance TDG classes by providing web-based technologies to create and present scenarios to the class, facilitate students joining the scenario in a classroom setting whereby the instructor can monitor and present student courses of action and evaluate students in situ or post-classroom session. A single server laptop can facilitate multiple classroom sessions with instructor and student devices (laptops, tablets, smartphones) replacing the traditional classroom's whiteboard and paper-and-pencil.

Prior to ITDG, the officer-of-the-day conducted one paper-and-pencil TDG per day with his unit. Collecting and grading TDGs was a cumbersome and unreliable process at best. Once ITDG was installed at V26, the officers recreated the paper TDGs as ITDG scenarios and hosted classes. Since each participant's course of action was recorded directly on his own overlay to the saved session, collection was built into the application and assessment could be done anytime during or after the class. This allowed V26 to identify strengths and areas for remediation.

Use of ITDG grew and evolved within the units, including conducting static force-on-force TDGs taking advantage of ITDG's overlay management system. Eventually, officers started using ITDG for mission planning and writing orders. The flow of communication increased through the posting of orders for field exercises with tactical graphics overlaid on the maps printed out from ITDG: battalion to company, company to platoon and so on. Finally, V26 utilized ITDG for after-action reviews, drawing out actions as they actually happened and comparing to the planned courses of action and integrating instrumented data from the exercise. An early example of an AAR showed how one unit was able to maximize overlapping coverage of its firing arcs by taking advantage of impassable terrain behind its position and decimating another platoon in an ambush.

HoloLens SandTable: a mixed-reality application hosted on the Microsoft HoloLens for collaborating in a SandTable Training Exercise (STEX) format on a 3D terrain model. Connected via a REST service API, ITDG and the SandTable are used together to execute a combined TDG/STEX exercise, sharing unit laydowns, tactical graphics, drawings and annotations. Using voice commands and hand gestures, users interact with the terrain, unit placement and overlay displays. Modes of operation include a "Collaboration Mode" where multiple users can share the experience of being gathered around a single physical sand table and a mode for projecting or recording the display from a single HoloLens to serve as a briefing tool. A deeper dive into the HoloLens SandTable can be found in (Longtin, et al, 2019).

<u>SPOTLITE:</u> a survey application used to record in-situ and post-exercise data from exercise participants and coordinators for tactical assessment and analysis.

<u>Spartan After-Action Review (SPAAR):</u> SPAAR collects and plays back exercise data, video and events from both live instrumented field exercises and virtual engagements, such as those conducted in the Spartan Tactical Games for playback and after-action reviews. The SPAAR integrates with ITDG for use as a map tool for AAR playback.

<u>Virtual Battlespace III (VBS3):</u> a first-person networked virtual simulation component of DVTE's Infantry ToolKit (ITK). VBS3 is used to conduct simulated tactical engagements for infantry team training and force-on-force missions.

Spartan Tactical Games Concept

As an incentive to use the Tactical Decision Rooms, the Spartan Tactical Games were instituted. The Spartan Tactical Games are regularly-scheduled virtual force-on-force competitions between units utilizing ITDG and VBS set in a bracketed tournament style of play, where the winning unit is awarded a trophy. A detailed discussion of the Spartan Tactical Games concept with analysis of results may be found in (Stensrud, et al, 2019).

Evolution of Tactical Decision Room to Tactical Decision Kit

Field exercises are the lifeblood of training for infantry units. Nothing quite compares with getting out in the physical environment and dealing with terrain, weather and all the stressors of executing a mission in the battlefield environment. Often, these units are instrumented with systems like the Integrated Tactical Engagement Simulation System (ITESS) to track unit locations, weapon fire and hit events and casualty status throughout a field exercise. The data gleaned from these systems can reveal valuable insight into a unit's tactical strengths and weaknesses and needs for remediation as the unit prepares for deployment.

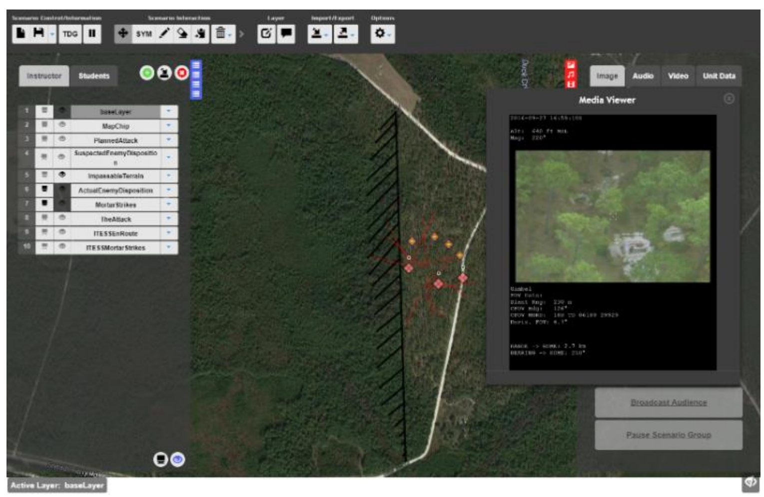

Figure 2. An Early Use of ITDG for AAR

V26 started looking at what resources were available for field exercise mission planning and AAR briefing. Primarily, these included paper maps, PowerPoint presentations and videos captured from ITESS recordings including position tracking, shots fired, hits and entity state changes. V26 first built a briefing package using ITDG (Figure 2) to reconstruct the mission plan, the actual situation and the aftermath of the exercise using drawing layers, unit symbols and tactical drawings, combining it with ITDG's multimedia support to play clips from the ITESS videos.

As the ability to create photogrammetric terrain models and maps was introduced and the HoloLens SandTable added the ability to display unit laydowns from ITDG, V26 explored the use case of bringing the ITDG and SandTable tools to the field to develop mission plans during a large MOUT field exercise, replace traditional paper maps, acetate sheets and grease pencils. This resulted in a significant reduction in the time to complete the planning process. Visualizing the 2D plan from ITDG in 3 dimensions in the HoloLens SandTable provided additional situational awareness to validate or modify aspects of the plan due to terrain considerations not obvious from the 2D map. Terrains produced from photogrammetry have the advantage of capturing foliage, rough terrain and building structures which affords the viewer the ability to virtually preview the terrain prior to an exercise (a virtual "rock walk" in Marine parlance). One

V26 company replanned their scheme of maneuver after discovering they would be traversing a narrow bridge along their planned route (a tactical error that could have had the whole company pinned down) that was only obvious in 3D.

Figure 3. Marines of V26 Using ITDG (left, photo by LtCol Marcus Mainz) and SandTable for Field Exercise Planning and MOUT Terrain Viewed from HoloLens SandTable (right)

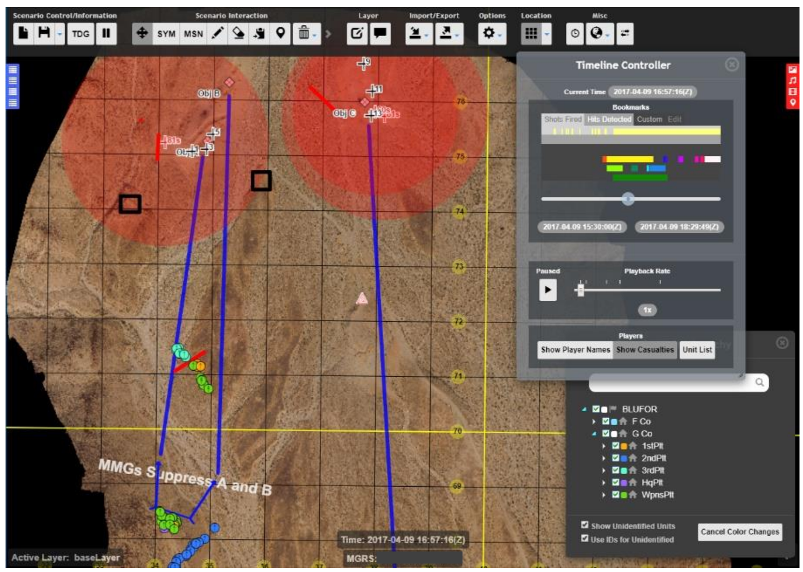

Figure 4. ITESS Playback in ITDG

Once mission planning became a feasible use case, the next question was whether the time to prepare and present an AAR using ITESS data could be made more immediately available. ITESS AAR briefing packages, comprised of analysis and video segments from instrumented engagements may take days or weeks to prepare before a unit commander has them available to brief. A more immediate use of this data for rapid debriefing at the range by the unit commanders while memories were still fresh was desired. Utilizing ITESS log files collected during or immediately following the exercise, a prototype import and playback capability was introduced to ITDG (Figure 4) and enhanced over the space of three major V26 field exercises and multiple smaller exercises at Marine schoolhouses. The resulting capability provided a battalion commander a tool to brief in less than an hour after an exercise showing movements of units and individuals, weapon fire engagements, casualty states with annotated overlays synchronized with user-inserted bookmarks. Additionally, if the ITDG application were used to develop the mission plans, the overlays developed for the mission plan could be compared to the actual events to inform on-the-spot mission evaluation and targeted discussion of events that affected execution of the plan. When combined with SPAAR, unit movements are synchronized with recorded video from the exercise, providing a complete picture of the events from several vantage points for a more effective AAR.

TACTICAL DECISION KIT COMPONENT TECHNOLOGIES AND USE CASES

ACMC Initiative for Tactical Decision Kit

In May 2017, the Assistant Commandant of the Marine Corps (ACMC) outlined the distribution and intended use of the TDK for active component infantry battalions. According to the directive, the TDKs would be distributed to "provide a means to challenge Marines to think critically, innovate smartly, and adapt rapidly in complex environments against adaptive enemies." (Walsh, 2017) The directive stated that each active infantry battalion would be issued a TDK over the subsequent eight months, and these TDKs were to be integrated into training and operational assessments.

The motivation behind this directive was to create "decision rooms" in barracks that would allow "competition within the units and enhance force on force virtual training for thinking adversaries." By integrating the TDKs into their training efforts, battalions would have "the ability to conduct live and virtual tactical decision games, develop graphic-based orders, mission plan in augmented reality, and then, in conjunction with ITESS equipment, brief, execute and debrief live missions." (Walsh, 2017)

Hardware

Hardware for the Tactical Decision Kits for each battalion consists of 3 Company Kits and a Battalion Combat Operations Center (COC) Kit (Figure 5). Company and Battalion COC Kit contents are listed in Table 1.

Table 1. TDK Kit Configurations

TDK Component	Company	Battalion COC
Server laptops for hosting the ITDG server, terrain processing and after-action review software	2	1
Client laptops with DVTE software installed to support VBS and DVTE CAN training or for ITDG clients	16	0
Microsoft HoloLenses	5	8
Microsoft Surface Pro tablets for ITDG clients or SPOTLITE input devices	4	4
Wi-Fi router	1	1
Network Attached Storage (NAS)	1	1
DJI Phantom UAS and Moto-G Flight Control Interface	1	1
Projector	0	1

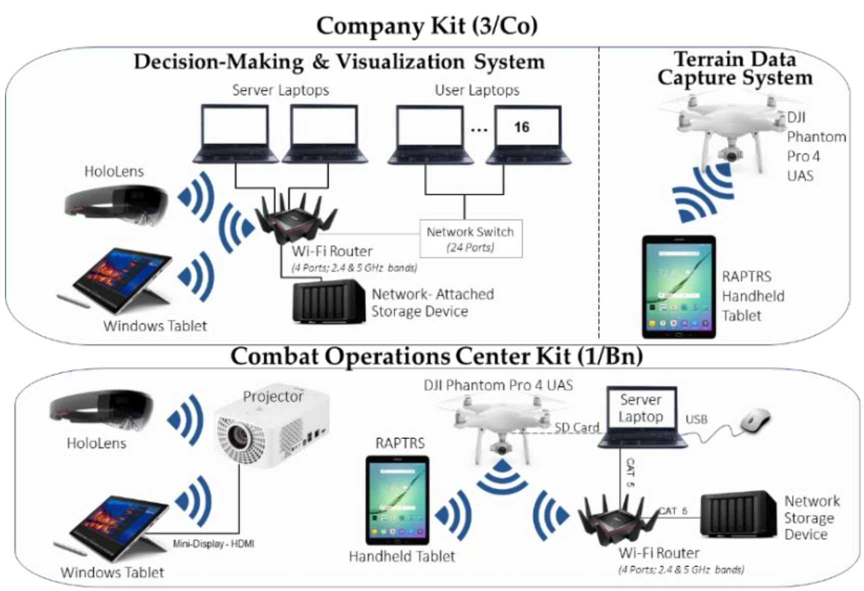

Figure 5. Tactical Decision Kit Hardware Components

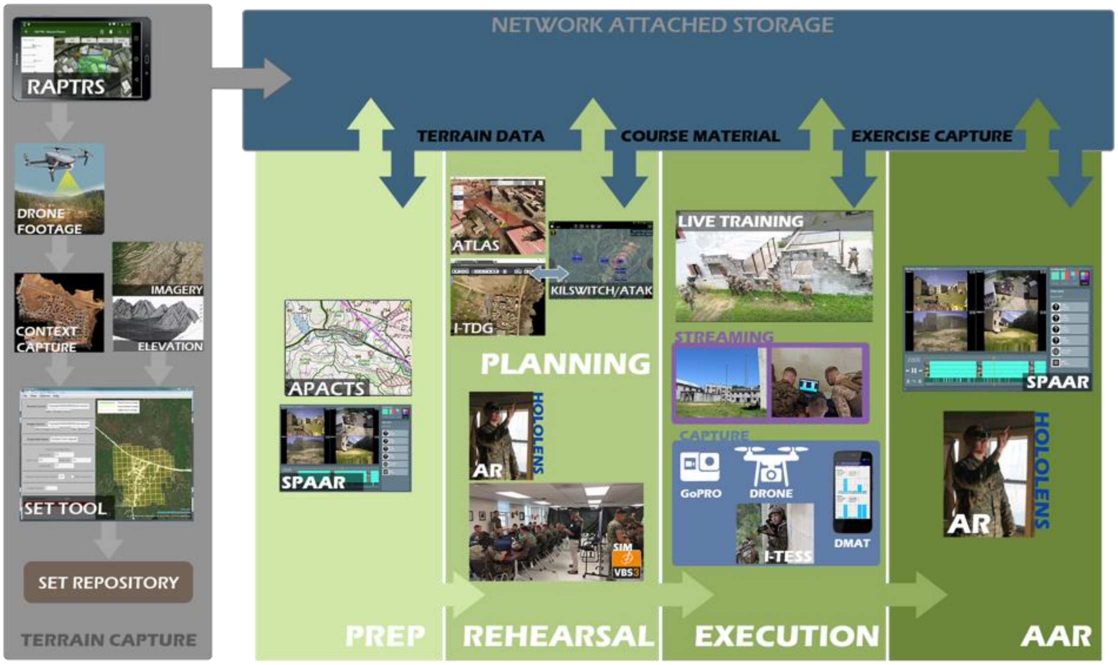

Figure 6. Tactical Decision Kit Applications and Usage

The TDK components address several use cases and flow from planning tasks through execution and after-action review.

Terrain Capture and Modeling

Whether preparing for classroom, virtual or a live training event, terrain is a key component of any scenario and is the backdrop upon which planning, execution and after-action-reviews are made. In a typical tactical decision game class, maps are often produced from scans of paper maps, screenshots from map applications, usually of actual training ranges, or drawings of theoretical locations. In virtual training, ready-made terrains are limited and may not be available for the desired training area. Building a new virtual terrain often takes weeks of work by 3D artists to produce a simulator-ready terrain for virtual and constructive simulators. In a train-as-you-fight paradigm, the ideal solution is for a unit to be able to quickly prepare its own high-resolution terrain models over areas relevant to the exercise. The Synthetic Environment Terrain Tool (SET Tool) was introduced as a component of the TDK that enables novice and expert users alike to create 3D terrains and 2D maps (Figure 7) for use within the TDK.

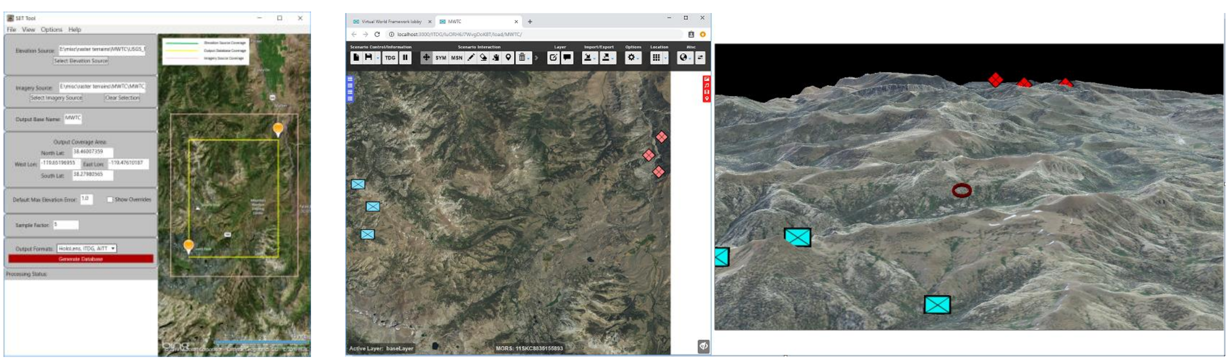

Figure 7. Synthetic Environment Terrain (SET) Tool (left) and Resulting Map and Terrain Products in ITDG (center) and SandTable (right)

Raster-based Terrains
Raster data, comprised of DTED and imagery overlays, may be acquired from the public domain, government agencies, S2 (military intelligence) shops, and other sources. However, data from these sources are typically medium- to low-fidelity in nature because the source data tends to cover extremely large swaths of land and are generated from data collected by high-altitude satellites or aircraft. Raster-based terrains essentially represent only the base terrain ("the dirt") and are perfectly suited for use when a scenario is based over a large area or when the terrain has little foliage or building features.

SUAV Photogrammetric Mesh-Generated Terrains
For smaller, higher-detail terrains, terrain models may be developed using imagery captured from overflights of small, cheap commercial drones. With the availability of commercial photogrammetric processing software and affordable high-end GPUs, a single laptop can produce a terrain model from hundreds or thousands of images in a matter of hours. The technique used in the TDK was adapted from agricultural survey techniques for farmers of crops using commercial drones (Delgado Vera, et al, 2017) and borne out from University of Southern California's Institute for Creative Technologies' research (Spicer, McAlinden & Conover, 2016) for simulation use. First, Rapid Aerial Photogrammetric Reconstruction System (RAPTRS) (Figure 8), software developed by USC ICT, is used to map a lawnmower pattern over the user-specified area, and when paired with commercial drone controller software, will pilot the drone through the flight pattern. The images collected, numbering in the hundreds or thousands, depending on the area covered, have sufficient overlap to create a high-resolution surface map (including foliage and building structures) in less than a day using a commercial photogrammetric processing software. One training area in the American Southwest covering 1.3 sq km took 55 minutes to process 599 images with a 25% downsampling factor, resulting in a 3D mesh model with a 30 cm accuracy. The resulting mesh model is post-processed to produce compatible terrain products for ITDG, SandTable and other applications.

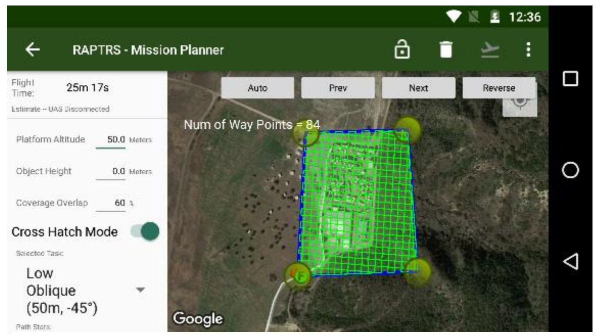

Figure 8. RAPTRS

Infantry units, with a minimal amount of training, were able to produce their own photogrammetric terrains and were ready to plan and execute a field exercise in less than a day's time. The resulting terrain model, while lacking some of the refinement that could be provided by 3D artists, provides a high-resolution surface-map model sufficient for mission planning as an organic capability of the unit.

Preparation

In the preparation phase, warfighters learn or refresh basic skills needed for planning and executing a mission. These include such skills as map reading and military land navigation. Understanding how to read a map and correlating that with a first-person understanding of the real-world environment is a critical skill that takes time to master.

APACTS
APACTS is a lightweight, web-deployable adaptive training system with a focus on land navigation skills. It provides tools for the instructor to author, analyze and adapt training for each trainee. APACTS has an AI-driven adaptive training model to automatically tailor remediation for each student. In an experiment involving 106 entry-level Intel Marines, those receiving APACTS tailored remediation saw an improvement of approximately 10% in their test scores over those who received traditional lecture-based training.

Planning and Rehearsal

Mission planning requires applying the tactical planning skills and doctrine as those taught to young officers in the Marine Corps at The Basic School Basic Officers Course (The Basic School, 2015). Traditional tools use paper maps, physical sand tables, hand drawings and text as well as Command and Control (C2) systems to develop, analyze and revise tactical plans, with contingencies, and create orders to execute the mission. Rehearsal may include a simple walkthrough of the plan with leadership, wargaming or simulation, if available. C2 systems, while powerful and tied into tactical networks, are available to a small cadre of trained personnel within a unit.

Interactive Tactical Decision Games

The Tactical Decision Game paradigm of ITDG lends itself readily to mission planning. The ability to use overlays with unit symbols, tactical graphics, drawings and annotations is a direct analogy to the same plans drawn out on acetate sheets and paper maps.

HoloLens SandTable

The HoloLens SandTable is a mixed-reality application for visualizing terrains, symbology and overlays in a given planning session. Like a physical sand table used in tactics training in schoolhouses or used in ad hoc planning (drawing in the dirt), the SandTable can be used to view a 3D terrain model anywhere in space, with users able to walk around or through the terrain space and view it from any vantage point. When synchronized with ITDG, the SandTable can be used to evaluate and develop a tactical plan, visualizing and interacting with unit placement and tactical graphics in three dimensions.

ATLAS

ATLAS (Figure 9) is a 3D desktop application which accepts full-resolution photogrammetric mesh terrain models and provides utilities to view the terrain from any aspect, visualize OPFOR and BLUFOR fields of regard and optimize route planning to minimize maneuvers through enemy lines-of-sight. Intervisibility between units and path planning features developed in ATLAS were also integrated into the HoloLens SandTable allowing the same analysis and what-ifs to be considered in either application. The intervisibility and path planning features were subsequently integrated into the HoloLens SandTable.

Figure 9. ATLAS

Execution

During mission execution, data is collected for after-action review.

For a virtual exercise, such as the VBS3 Spartan Tactical Games, this means collecting data via HLA or DIS network. VBS3 has a built-in AAR replay capability that was used for the purposes of the Spartan Tactical Games.

For a field exercise, data collected during execution includes:

- ITESS-instrumented Marines (providing position of individual Marines, shots fired, hits, casualty status)
- Camera feeds (may include fixed cameras with live RTSP feeds or sim-card downloads from GoPro or drone cameras)
- SPOTLITE surveys and reports (more about SPOTLITE in AAR)
- DMAT-recorded events

DMAT

The Decision-Making Automation Tool (DMAT) is an Android app which is user-configurable to record engagements and critical exercise events during execution. Typically, this is used by an instructor or exercise observer and replaces or supplements the notebooks used to record the same data. Built-in analysis tools provide reports on the occurrence and statistics such as frequency of the events and recorded event data may be exported as bookmarks to SPAAR to support after-action-reviews.

After Action Review (AAR)

After Action Review is a standard practice to draw out lessons learned following an exercise to gain “feedback on mission task performance” and “correct deficiencies, sustain strengths and focus on performance of specific mission essential tasks lists (METL) training objectives” (Headquarters, Dept of the Army, 1993, p ii). The TDK offers a unit an ability to replay collected video, position and location information (PLI), shots fired, hits and casualty status through the instrumented ITESS data recordings and unfold those events from 2D, 3D and video perspectives.

Additionally, if the TDK was used to plan the exercise, the original mission plan and the actual events can be directly compared and an assessment of a leader's tactical planning strengths and deficiencies can be identified. Additionally, since the TDK is organic to the unit, these tools may be used almost immediately following the exercise.

DM-LMS and Spartan After Action Review (SPAAR)

SPAAR is a web-based software tool that supports synchronized replay and annotation of recorded live and simulated training exercises with a relational database back-end (DM-LMS) to store, index and stream recorded data for after-action review. The concept of operations supports the logging of live (e.g. ITESS) or simulated state data from an exercise, insertion of exercise content from instructors, video and audio content synchronized with state data in a multi-view display for exercise analysis and AAR. Video sources include individual-worn cameras (e.g., GoPros), fixed cameras and drone video. Synchronized playback from all these sources allows a unit to perform a comprehensive AAR from a variety of different perspectives.

Figure 10. Spartan After-Action Review Tool with ITDG and Video Quad View (left) and Camera View Quad (right)

Interactive Tactical Decision Games

ITDG was extended to include play back of events captured during ITESS-instrumented exercises and virtual exercises (such as Spartan Tactical Games). Data is either ingested from ITESS output files or streamed from DM-LMS and synchronized with SPAAR. This provides a plan view display of position, shots, hits and entity status for SPAAR during playback while synchronizing with video collected during the exercise and the drawing tools built into ITDG to annotate the exercise as it unfolds.

DEPLOYMENT

Deployment of the Tactical Decision Kits began in May 2017 to all 24 active-duty Marine infantry battalions and two schools of infantry (SOI-East and SOI-West). Through Feb 2, 2018, of the 24 battalions and two Schools of Infantry, 18 Tactical Decision Kits had been deployed. Due to deployments and other scheduling conflicts, the remaining kits were delivered over the course of 2018. A mobile training team (MTT), consisting of two facilitators, provided a course of about 4 days of setup support, briefings and basic training on the use of the elements of the tactical decision kit, with hands-on training of the Spartan Tactical Game concept and Field Exercise Terrain Development, Planning, Execution and AAR using the components of the TDK.

User Impressions

The MTT issued surveys to the units receiving TDK training. The surveys included 15 ratings on aspects of the TDK and MTT training session and 3 short-answer questions. Ratings values ranged from 1 (strongly disagree) to 5 (strongly agree). Over the same period covered by usage data collection, there were 174 surveys collected. Out of the sample, 3% of the ratings and 29% of the short answer questions were left blank. The respondents' population by rank is shown in Table 2.

Table 2. Marine Survey Respondents by Rank

Rank	E-2	E-3	E-4	E-5	E-6	E-7	O-1	O-2
Count	14	89	42	16	1	1	4	7

E-4 through O-2 ranks cover the ranks of leadership between fire team leaders (E-4) and platoon commanders (O-1 and O-2) and encompass 40% of the respondents. These ranks have increasingly more training and experience in leadership and tactical planning than the junior enlisted ranks (E-2 and E-3).

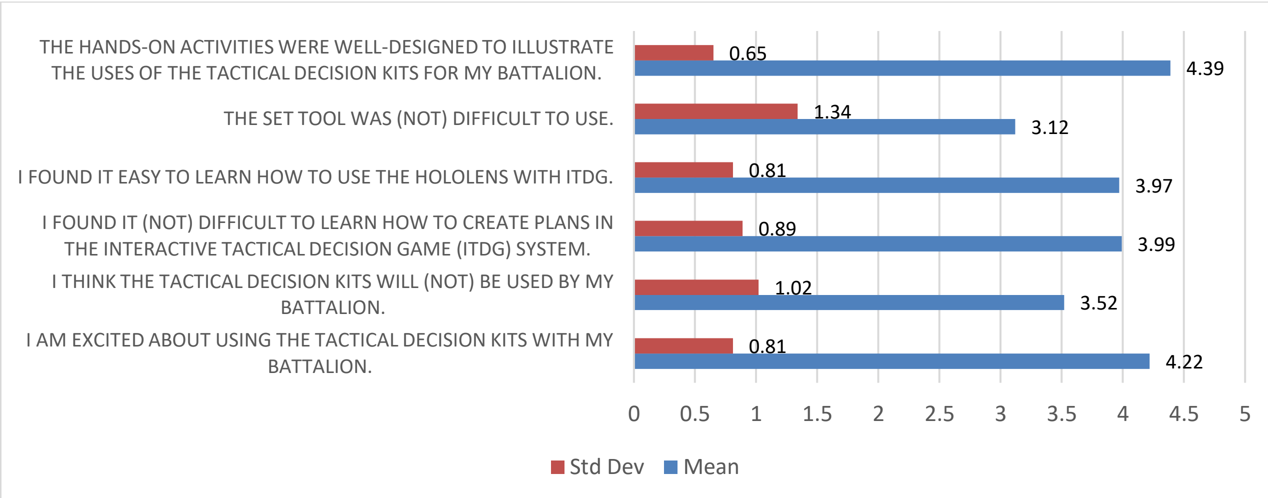

Figure 11. Marine Survey Rating Responses

Generally, the TDK was well-received by the respondents and they felt that the TDK components were easy to use, the SET Tool being the most difficult application, and the MTT training provided a sufficient introduction to using the applications for their tactical training needs. An interesting takeaway is that the respondents were excited to be able to use the TDKs, but they were more skeptical that the TDKs would be used by the battalion. Per the ACMC's directive, the TDKs are an experimental platform for battalion commanders to use as they saw fit, so there could be an uncertainty among the respondents as to their battalion commander's operations concept. This discrepancy may also reflect the opinions of the large number of respondents being in the junior ranks versus the more likely audience of NCOs, staff NCOs and officers.

FUTURE EXPANSION

Spectrum Operations

Infantry commanders are increasingly more aware of the electromagnetic spectrum in the battlefield. A commander who understands the implications of turning on an emitting device like a radio or capabilities of enemy emitters, receivers and sensing devices has a better opportunity to plan maneuvers and evade detection or locate enemy forces. The ability to configure and visualize the electromagnetic landscape is being integrated into ITDG and the HoloLens SandTable under an ONR program. An initial capability has already been delivered for TDK 2.0. For more information on Spectrum Ops and the HoloLens SandTable please see (Longtin, et al, 2019).

Physiological Tracking

The proliferation of wearable physiological tracking devices, such as smartwatches, fitness bands and chest strap sensors bring a capability to measure biometrics, previously limited to pilots in cockpit simulators, to the infantry soldier or Marine. There is an urgent need to monitor and measure extreme stress and heat-related injuries using metrics such as heartrate and core body temperature. In one 4-day field exercise in the heat and humidity of Camp Lejeune, NC, over 40 Marines out of a battalion of approximately 800 succumbed to heat exhaustion and required treatment for heat-related injuries. This is acknowledged as a general concern that extends from training to overseas deployment. Under an ONR research and development effort, in concert with AFRL and the US Army, integration of a physiological monitoring and after-action-review capability is being integrated into elements of the TDK as part of an attempt to address the push to instrument and track warfighters' physical and psychological condition (Scales, 2018).

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