Re-Thinking the Tactical Small Unit Synthetic Training Model

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ABSTRACT

In future warfare, long range precision weapons and cheap remote and mobile sensors will practically eliminate the traditional large ground-unit tactical maneuver against “near-peer” enemies. In its place, tactics and maneuver will consist of decentralized and sometimes isolated tactical small-units (TSU) – characterized as squad and smaller units. These TSUs will have to fend for themselves, have greater responsibility, and greater ability to survive, sustain and fight as self-contained entities (Scales, 2019).

Historically 90% of all military force casualties occurred in TSU close-combat (Roper, 2018). In addition, in the last modern ground wars, TSU extreme violence close-combat often resulted in “fair fights” against relatively inferior, ill-equipped opposing forces (Roper, 2018). What this means is in future warfare, TSUs will be challenged to gain or sustain *overmatch* with enemy forces in a prolonged ground war without improving how we train those forces. Such close-combat lethality “matching” should never happen with the degree of investment in synthetic training technology being developed for infantry TSUs today. Unfortunately, it may if new synthetic training technology is used to train TSUs the way they’ve always been trained over the last several decades which resulted in the outcomes above.

The future synthetic training model will be a critical technology and learning model to build and sustain *overmatch* in the future warfare US Army and Marine Corp TSUs. This new model will include the ability to rapidly develop and sustain combat team cohesion, maturity and individual combat competency through experiencing multiple synthetic “bloodless battles.” New architectures, engineering practices, competency structures, live-data based stimulus and assessment, machine learning (ML) and artificial intelligence (AI), and new organizational changes to unit level training will both increase the development rate and quality of future TSU overmatch. The ideas presented in this paper are considered as necessary changes to achieve that goal.

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INTRODUCTION

In a future war, long-range surgical enemy firepower will expand greatly, supported by multiple high-resolution battlefield sensors of various sizes and types (US Army TP 525-92) that could essentially eliminate the element large force maneuver in traditional linear combat tactics against "near-peer" enemies (Scales, 2019). In this setting, the future Army will likely rely more on the quantity of general infantry tactical small-units (TSU) as a decentralized thrust of dynamic maneuver to minimize detection by pervasive sensors - to obfuscate maneuver and intent, and to prevent mass-casualties from high-precision long-range firepower.

At the same time, historically 90% of all US military combat casualties over the past eight decades occur in TSU infantry close-combat (Roper, 2018); TSUs are characterized as squad and smaller level forces. Based on this trend, future Army general infantry TSUs could be severely challenged to sustain themselves in a prolonged future ground war without having what's termed overmatch against enemy forces. *Overmatch* is here-in characterized as a TSU possession of competency levels that, when applied over time against opposing forces (OPFOR) in combat conditions, those forces are neutralized without avoidable loss.

Military close-combat is an environment characterized by opposing TSU infantry engaging in extreme violence within line-of-sight of each other. In the last modern ground wars fought in Iraq and Afghanistan, such close-combat often resulted in many friendly casualties because of "fair fights"; fights against relatively inferior, and ill-equipped opposing force. In the future, such close-combat "matching" should never happen with the investment in training technology being provided to our general infantry TSU soldiers today.

To build *overmatch*, this paper suggests the US Army needs to revisit how it prepares and readies its TSUs today by employing new capabilities and policies that will maximize the effectiveness and return-on-investments in the future Synthetic Training Environment (STE). STE, with its new high-resolution synthetic modeling engines and Training Management Tools (TMT), needs a concept of operation that moves beyond how the Army trains TSUs today. STE-TMT will be a core capability in the delivering and tracking the multiple "bloodless battles" that will help rapidly elevate team cohesion and individual expertise in combat competencies. Using capabilities like adaptive architectures, competency structures, live-data based stimulus and assessment, machine learning (ML) and artificial intelligence (AI), and a new Army TSU training model, together can increase the rate and quality of TSU combat lethality.

The ideas presented here-in are necessary to both overcome the limitations of current TSU training model and practices, and to support the inherent need for rapidly creating, sustaining, and managing infantry TSU competency overmatch against potential enemy near-peer combatants. STE will be a critical and strategic tool in the creation and replacement of infantry TSU teams and soldiers for the (yet-to-be-experienced) future battlefield. Our premise is that to achieve and sustain TSU overmatch goals in this future context, the US Army needs to modernize its existing TSU training policies and methodologies that have been in use for over half a century.

CURRENT TACTICAL SMALL-UNIT TRAINING POLICIES AND PRACTICES

According to Army and Marine Corp field manuals, the TSU's mission is "to decisively defeat, destroy, or neutralize the enemy force, or to seize key terrain." On defense, it is "to repel, to defeat, or to destroy an enemy attack and to gain the initiative for the offense."

In the execution of those missions, "the Infantry… squad must be ready to adapt to various levels of conflict and peace in various environments," according to Army Directorate 3-21.8, published in 2016. Add on top of these the requirements described above for TSU employment in future ground wars.

These TSU missions are and will be accomplished through a series of critical tasks TSU teams and their soldiers must be competent to perform on demand. Today training needed to build competency in those mission-tasks above occurs as part of a larger traditional deployment cycle-based unit training plan (UTP) or “waterfall” type training model (Department of the Army, 2019). In this model, TSUs are the first phase of an expanding series of episodic training “gates” and events that are designed to enable higher echelon training to build upon previous lower-echelon accomplished training. These phases of training occur with very little formal performance data tracking (other than physical fitness and weapon qualification); without such data, readiness levels or gaps cannot be identified. Once the lower echelon TSU training phase is over, TSUs are then “used” to support higher echelon training instead of continuing to improve upon an established baseline from the early phases of training.

The TSU training phase begins in scheduled periods called “Training Weeks” (aka “T-Weeks”), which scaffold up, beginning with teams and crews, to the company or squadron echelon level of training, when TSUs basically become “training resources” for accomplishing the higher level “mission essential task” training objectives. TSUs conduct their respective, necessary basic training up front during the T-weeks, after which, and in theory, they can apply their new/refreshed knowledge and skills in the multiple, and larger follow-on “collective” training events. While this makes sense and even follows traditional models of training, in practice, TSUs have very limited time and little control over what tasks they can train on during these later higher echelon training exercises, so it is difficult to build or sustain all the necessary mission-task expertise, and required levels of team cohesion, necessary to perform the above TSU missions at the highest levels of readiness.

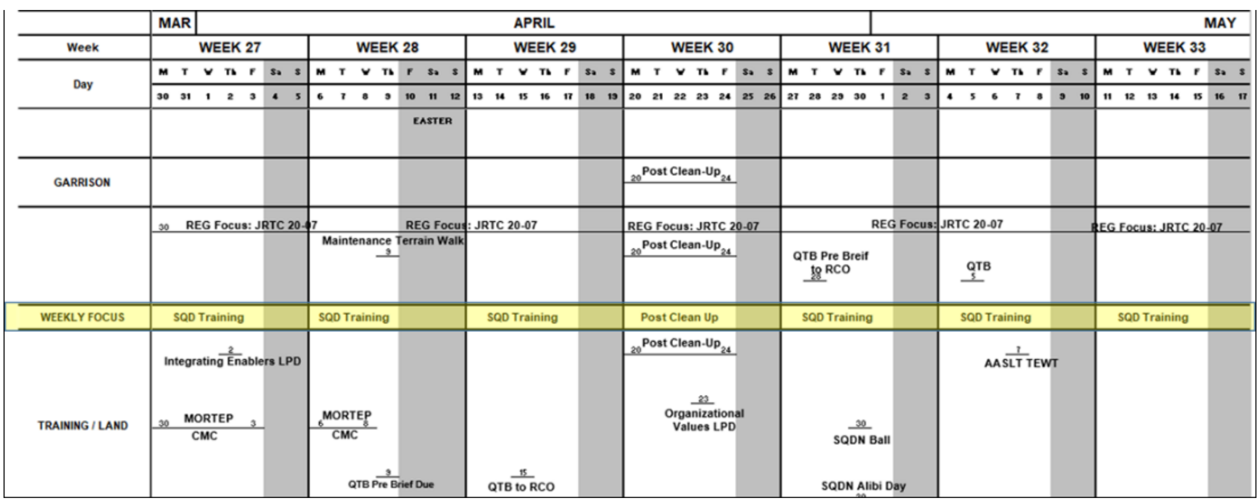

Figure 1. Example of Army Unit Training Plan with designated TSU-level training weeks or “T-Weeks”.

The sheer number of competencies a TSU must attain and/or sustain is challenging by itself but what is even more challenging is the lack of time allocated to TSUs to accomplish the training necessary to gain or sustain those competencies. Time is further reduced by competing non-combat related mandatory training TSU personnel must accomplish. In addition, there are many other non-combat related tasking placed on TSU personnel at home-station (e.g., gate-guard duty, trash and lawn maintenance details, acting as swimming pool life-guards, etc.…) that removes additional time from training on core combat competencies. Missing is a more formal, continuous and accountable process of TSU assessment and responsive/recurring training that continues indefinitely, and does not cease once the currently finite TSU “T-Weeks” are over.

Leaders are challenged with Team Leadership and focusing on their own Training simultaneously.

Another challenge is the organization and support required to achieve higher quality TSU training. While more than capable of providing basic knowledge or skill training, when executing TSU collective (team) task training, it is extremely difficult for a TSU leader to both lead the team’s task performance, and concurrently perform in a focused training/assessment role during the practical exercise. Like all humans, team leaders are extremely challenged to assess their own people, let alone themselves objectively and without bias. In addition, leaders need to observe and assess an average of 7-9 members in a Squad concurrently with the naked eye, and with equal degrees of scrutiny, which humans simply aren't capable of.

The TSU leader/trainer is also challenged by the inherent human limitations to recall from short-term memory the exponential growth of team activities that occur over a team training exercise, even during a short session. All these challenges and limitations suggests the US Army needs to adopt and implement new TSU training protocols in which, unit TSUs would no long assess themselves but would assess one-another across a unit, and in combination with other adopted practices and technologies noted later to ensure better quality training, assessment and TSU feedback occurs.

FUTURE TACTICAL SMALL-UNIT SYNTHETIC TRAINING CAPABILITY REQUIREMENTS

In the future, the requirement of synthetic training systems will be to create realistic combat environments that rapidly develop the necessary TSU overmatch state and associated level of lethality. This includes elevating the competency of TSU collective and individual tasks, tactics, techniques, procedures (TTP), as well as underlying knowledge and skills. Assessment and instruction will be supported by automated ML/AI-based technologies, and the currently high administrative workload for unit readiness reporting will be significantly reduced. Together these capabilities will allow units and TSUs to record and track their actual performance over time and compute their degree of competence and overmatch, in high-stress realistic-combat conditions over a sequence of realistic "bloodless battles."

The STE will need to produce a level of believable realism and covert clues that induce the same stimulus felt on a battle field, that develop honed mental instincts for correct rapid decision-making in response to ML/AI enhanced synthetic OPFOR actions. STE will also need to simulate cyber-threat conditions, when many of the Army's technological advantages may be denied or limited. Finally, the STE will also need to reproduce enough visual, aural and psychological combat-related stress, so that future TSUs can become more *inoculated* from such stressors… so that they can stay in the fight longer.

Future Modeling and Simulation (M&S) Architectures and System Engineering Processes

Future simulation design requires M&S architectures as a service (MSaaS). This will be an extension and enhancement of current army regulations for Army M&S (Department of the Army, 2014). MSaaS is like a Modular Open Systems Architecture (MOSA) approach but demands greater architectural adaptability as well as open system standards (Hannay, Van Den Berg, Gallant & Gupton, 2019). The premise of MSaaS being that simulations can be composed quickly using loosely coupled and shared components and simulation services, in a cloud environment. This allows services such as new or different environmental elements, OPFOR or neutral forces (NUFOR) character models and combat capability behavior models witnessed and recorded on the battlefield to be rapidly incorporated into synthetic training stimulus, as well as ML/AI based data interpretation or assessment algorithms. In this way, synthetic training system architectures can rapidly adopt these necessary training changes without requiring the legacy expense and delay from "hard-coding" fixed and/or proprietary architectural solutions. This notion is paramount to support other ideas below such as *re-experiential based simulation* that will demand rapid changes to support new small-unit combat challenges or gaps detected on the future battlefield or that future soldiers will need to rapidly build combat experiences in.

Another supporting architectural requirement is that of a Joint Training Synthetic Environment (JTSE) which supports a larger Joint Federated Common Data Services (JFCDS) across DoD (Dvorak, et.al, 2019). This form of synthetic architectural ecosystem allows any synthetic training exercise author to rapidly locate, access, transform, transmit and/or distribute authoritative data. JFCDS, in concert with MSaaS, will support the idea of simulation based on re-experiential simulation using live recorded data; data from one service that applies to other services can be meta-tagged and re-used only within another service's context – e.g., system diagnostic and troubleshooting aircraft engines or engaging with common weapon systems.

To achieve this design pattern, future M&S architectural modules and services must be integrated through open-standard Application Program Interfaces (API). This prevents establishment of proprietary architectures and enables service-level updates by any vendor via Army Science and Technology (S&T) labs. A great model of a MOSA architecture is the Army's Generalized Intelligent Framework for Tutoring (GIFT) (https://gifttutoring.org/), which is being used as a prototype for future STE-TMT features and capabilities (Sottilare, Goldberg, Brawner & Holden, 2012; Goldberg, Hoffman & Graesser, 2020). GIFT is MOSA-based and applies a set of best practices and data services to assess performance and inform intelligent tutoring functions (e.g., provide feedback, ask a question, adapt scenario, etc.).

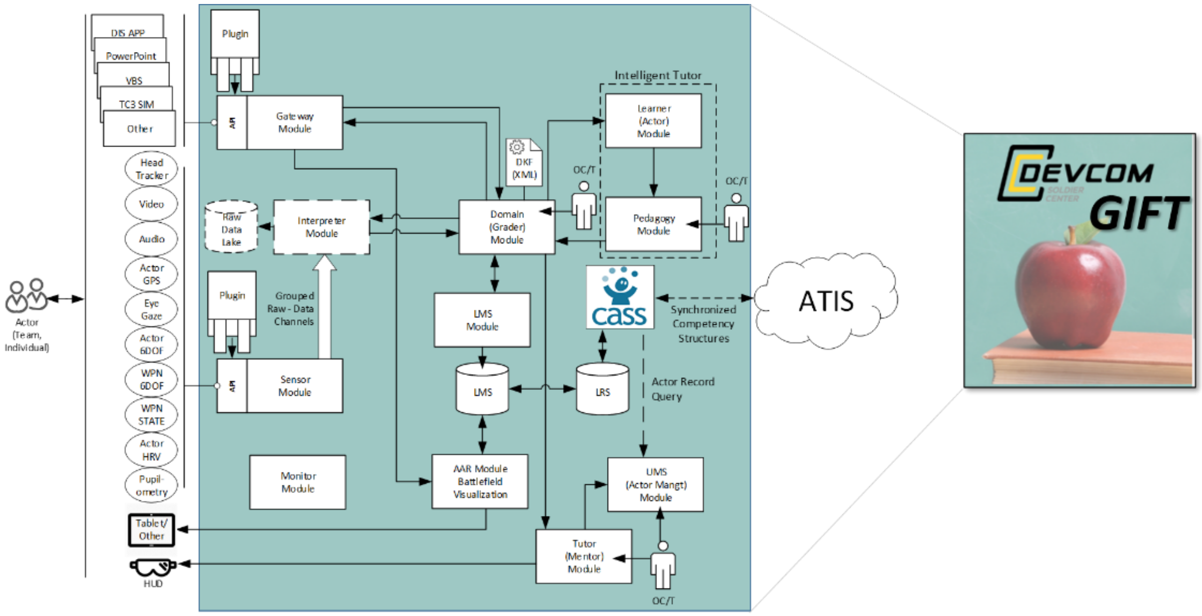

Figure 2. Example of MOSA Architecture - GIFT

Within this JFCDS vision, each of the GIFT modules in the Figure 3 can be easily replaced or upgraded with common data service modules or content packages without any major recoding, and the content the modules process can also be rapidly modified without substantial architectural impact. Currently a key design requirement for future STE-TMT is the integration with both high- and low-level performance data tracking (e.g., unit level to soldier-level), integration of realistic, sharable, reusable training exercises linked to task competency levels, and an ability to both consume and feed services like training scheduling, readiness reporting, and team / soldier performance data storage afforded by centralized authoritative structures like the future Army Training Information System (ATIS) (https://www.atis.army.mil/Index.html), and through an optimized and intuitive user experience. In addition, other parallel Army efforts to improve TSU performance like the Squad-Overmatch and Squad Performance Model projects will only be enabled by a MOSA architecture so they can rapidly extract and/or feed STE with their unique capabilities and/or data.

Another element that must accompany the MOSA architecture is the practice of User-Centered design. This means incorporating system engineering practices that are focused around a composite human-persona of the actual system users and learners (soldiers). Future synthetic training systems also must be tested not only on how well they work but how well they help teams and soldiers achieve the competency levels they need to achieve with a synthetic trainer. No longer can M&S be developed in a bubble of improved technical features and capabilities without ensuring the instructional systems they are a component of can perform their capabilities in an improved manner as well. This requires that M&S system engineering requirements be first and foremost based on the competencies the instructional systems it needs to support are focused on. In addition, system engineering must be based on working models of "trainer/learner-journeys" to ensure that M&S systems are easy to use. This includes producing optimized and intuitive user-flows ahead of time, and refined through multiple user touch-points. These extra steps will ensure rapid M&S adoption and provide a user experience that promotes a desire to train – even in the most austere or harsh conditions.

Competency Based Structures and Evidence-Based Competency Assessments

One of the key ingredients for a successful future TSU synthetic training model is the need for standardized, well-defined, and data-supported combat competencies. Competencies allow us to understand and track the underlying characteristics of an *actor* (a soldier or team) that is causally related to criterion-referenced effective and/or superior performance in a job or situation (McClelland, 1993). Modern competency definitions and reporting standards are being developed by standards-groups like the Institute of Electrical and Electronics Engineers (IEEE) as well as working groups of the Army Learning Concept 2035 (TRADOC, 2017), which includes this new competency-based learning (CBL) capability. DoD sponsored competency management systems like the Competency and Skill System (CaSS) (https://cassproject.org/), along with many other supporting capabilities will provide the opportunity to fold in CBL (ADL, 2018) and associated skill acquisition (Dreyfus & Dreyfus, 1980) into future TSU level training management systems like STE-TMT.

The TSU combat-performance standards that competencies represent will not be much different than what the US Army and Marine Corp currently define in their respective TSU task structures. What competencies will add to this structure is a much more standardized, flexible, and extensible framework that includes more novel yet common performance conditions, best-practice and technology-based methods of performance assessment, and fair and data-based criteria for meeting competency requirements. This together will greatly improve the currently verbose and static readiness "check-list" standards in use today - e.g., the Training and Evaluation Outline (T&EO).

A competency structure consists of what can be thought of as *complex* and *simple* competencies. Simple competencies are primitive performance capabilities such as knowledge, skills and attitudes, (KSA). Complex competencies consist of any collective task that requires accomplishing other complex competencies and/or simple competencies, and in any combination. Competencies can be targeted for organizational teams (echelons) or individual job or role-based readiness qualifications, and in the case of teams, will consist of both. Modern information structures such as dynamic *relation* linkage between competencies will add efficiency with an ability to "re-use" just one specific competency standard for different tasks or actor structures instead of the confusing practice of the same task standard being re-written in different syntax within different task T&EOs.

For complex competencies, a consistent standard is needed for how a readiness credential is fairly but reliably awarded; this is critical to ensure readiness means the same to all combat commanders, and even different military services (or allied nations) needing the same level of competency. Consistency and fairness are provided through what are called *Roll-up Rules*, which is a form of competency manifest that will ensure all required competencies have been assessed at a set level for TSU's and soldiers to earn credentials of readiness. With the help of universal learning records, competency management systems, and credential management systems, the administrative process to manage competencies and readiness will become almost automatic, and *much* easier for the Army's TSU leader to manage than current methods and processes.

A critical element of TSU performance that competencies shall support is new forms team-based training, assessment and feedback. This attribute of future TSU training is expected to bring the biggest impact to TSU overmatch improvement in the future based on the TDT construct noted earlier. A competency structure provides linkages to subordinate and supportive tasks and KSA based on first-order effects, direct impacts on accomplishment or prerequisite and enablement of a given competency. Competencies would apply to any / all live, synthetic, or instructional training and assessment methods - whether they reside in a schoolhouse, at a home station combat gym or at a deployment site - so that the Army can maximize the "re-use" of already invested content, best practices or rapidly adopt competency structures proven effective in other military services or civilian practices.

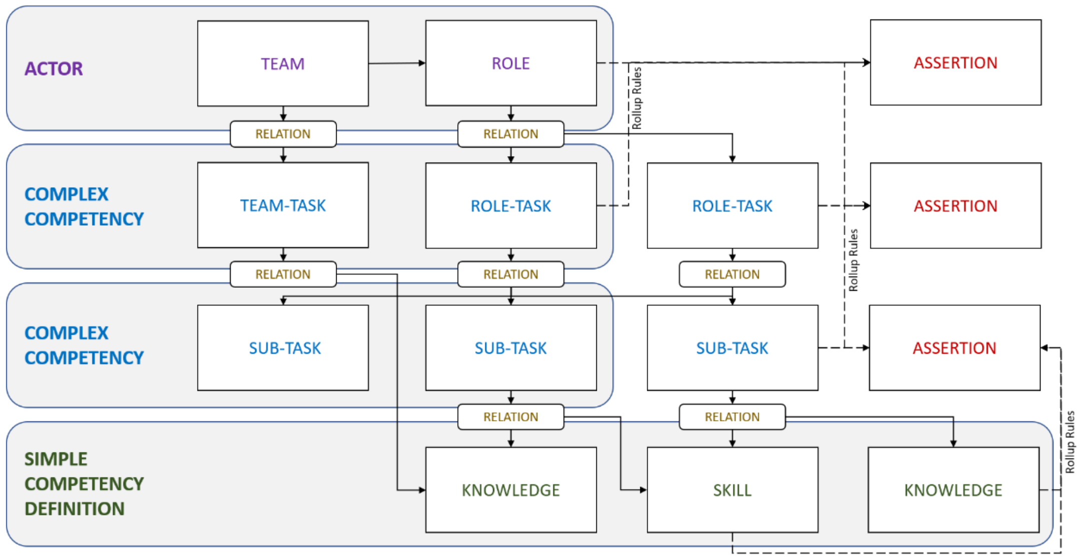

Figure 3. A Competency Framework

Most importantly, a competency structure, as shown in Figure 3 above, provides a documented and centralized system of "claiming competency" (a.k.a. *assertions*) at any level of performance. Assertions are the information and evidence that support certain credentials like TSU qualifications (readiness states) or even individual qualification – e.g., Army "tabs" (arm-worn specialty insignias). On this last example, wouldn't it be great if every soldier's MOS provide them a means to show their excellence in their professional field in addition to structured programs like Airborne, Rangers, Special Forces, etc…. Instead of the traditional assertion process being subjectively decided at the end of a course through a summative "GO" or "NO GO" assessment, or even a claim from "word of mouth" (as is typically practiced in industry today). A competency structure always allows automated and objective mechanisms to not only provide consistent accounting of competency levels but affords any reviewer the opportunity to inspect and trace back competency evidence – to the point-of-performance –the claiming agent or individual(s) used to the assert a competency.

A competency management system makes this assertion and evidence accounting process more accessible and reliable but also ensures assertions are finite, meaning that no-longer is a team or individual competent for "life" – i.e., retaining credentials despite fact one has not performed a task, job, etc... for many years. As part of the future TSU training model, performance data will always be recorded during training and even in live performance to provide evidence. Like today's police video cameras, this evidence will be used ONLY during times of assessed performance to analyze for competency improvement as well as support any claim of competency (positive or negative), including the level and realism of the combat experiences perform in. This new policy and practice will not only make TSU readiness measures more reliable and valid but make credentialing fairer, and promote greater motivation and inter-unit competition for TSUs to train harder based on honest/fact-based feedback.

Experience Based Expertise

Aristotle stated, "Excellence is an art won by training and habituation. We do not act rightly because we have virtue or excellence, but we rather have those because we have acted rightly. We are what we repeatedly do. Excellence, then, is not an act but a habit". This ancient principle of human learning is prolific and instructive to future TSU training. Today research has taught us that learning is fundamentally a product of experience (National Academies of Science, Engineering, Medicine, 2018). Soldiers construct comprehension, memories and complex models of team performance, tactics, and procedures based on experience in realistic task domains because of associated emotional feedback received during or after performance.

Expert performance is predominantly developed through deliberate repeated practice (of tasks) (Ericsson, K, et.al, 1994) and the acquired experiences from novel conditions that comes with it. Experience is the builder of mental faculties in the human brain (referred to as *intuition*) that transcends beyond the limits of memorized static rote knowledge, as most occupational training curriculum today is based. In addition, feedback is the critical ingredient that forms expertise, based on its inherent emotional response to success and/or failure. This response triggers motivation to improve but also strengthens the ability to recall the experience more instinctively because of repeated recalls of the memory of events in post analysis (aka reflection).

These principles are developed through methods such as intuition skills training (Klein, 2003). The extensible cycle of novel experience, the recall of recent and long-term experience, and data/fact-based feedback on performance are what together will be referred to here-in as extensible-experiential-expertise or *X-learning*.

In past wars from Vietnam to World War II, it took months for TSUs to build team cohesion because new replacements had little to no combat experience. The training new soldiers did receive was based mostly on basic rote KSA level instruction; therefore, replacements were perceived as a danger to the mission and to other members of the team. As such, new soldiers were often ostracized and neglected until they gained enough experience in combat which didn't occur for several months, if they didn't become a casualty first. There was no mechanism back then to allow new replacements to rapidly gain the combat experience and battlefield wisdom front-line TSUs have, and which they were being asked to replace. Also affecting new replacement TSU's and soldiers was the stress that comes from the initial horrors, chaos and ambiguity of combat, that basic training never really exposed them to before they perform their first combat mission. This leads to one reason why the Army is interested in exposing TSUs and soldiers to multiple synthetic "bloodless battles"; so TSUs and soldiers can rapidly accumulate such grit from even synthetic experience.

A key bonus from performing in synthetic combat is that the training return-on-investment (ROI) goes higher with each repeated failure. Thomas Edison famously stated that, "I have not failed 10,000 times. I have not failed once. I have succeeded in proving that those 10,000 ways will not work…". Every time a soldier becomes a casualty in synthetic combat or causes damage to synthetic equipment or systems in training, they are adding training ROI from the loss that would have otherwise costed the Army if it had occurred in live performance. Synthetic training increases ROI because its faster to reset and train against a realistic stimulus or problem and correct any mistakes made in previous attempts. In short, TSUs and soldiers should want to be challenged, make mistakes and to train against problems that are realistically difficult to them. Like weight-training muscles, a key to competency growth is ensuring an exercise's level-of-difficulty is slightly higher than a TSU's or soldier's current competency level; it is simply the natural way humans develop through X-learning.

How much X-learning does it takes to reach Aristotle's level of "excellence"? That is a major question that only future TSU training research and tracking can together answer through data; it will likely be different lengths for different conditions and competencies. Research has found that by an early age, top-performers of certain skills had practiced on average 10,000 hours each or approximately four-times the amount of practice and experience over that of less accomplished performers (Ericsson, et.al, 1993). This difference is what produces the *excellence* cited by Aristotle, and how infantry TSUs will gain overmatch against potential future enemies. Next is sustaining that excellence over time, which the future TSU training model must support (more below). As noted earlier, what we can surmise is that it will require significantly more practical combat experience and opportunity than soldiers receive today, and will require TSU training policies that support providing that additional time to build *habitual excellence*.

Human-System Assessment, and Long-Term Data Storage

In the 1980's, Dr. Edward Deming noted that, "… the aim of leadership [and training] is not merely to find and record failures of men but to remove the causes of failure; to help people do a better job with less effort". To do this today we need to improve the way performance is assessed and measured, and to do that, we must extend man's limits *with* machines. The fact is that today, for any echelon of military training, the human observer-controller/trainer (OC/T) alone simply cannot monitor, track, and assess all the parallel performances going on, even at a small-unit level - in short this is a human workload challenge. This premise is supported by past Army research of Training and Evaluation Outlines (T&EO) use which found them to be too detailed, difficult to use and not helpful in AAR outcomes (Fober, 1997). What wasn't available at this time was the technology to support this problem which is today ML/AI based support algorithms.

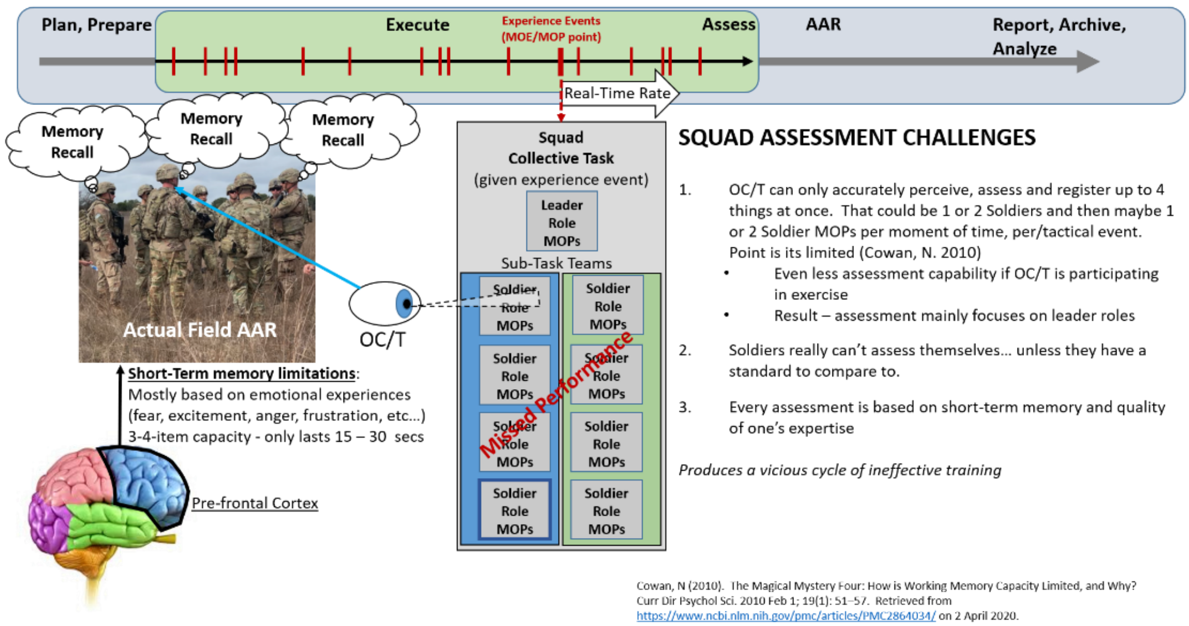

Figure 4. The TSU (Squad/Team) Training and Assessment Challenges during Practical Training

To meet this challenge, a new form of competency-based automated assessment is required. This involves initially providing the OC/T with competency centric human-machine interfaces that not only simplify the assessment and assertions of competencies as noted above, but helps *train* future ML/AI services that will eventually assist the OC/T in their logical inferences from their observations to find the simplest and most likely explanation (the abductive reasoning process) of what occurred, in support of the learning exercise's competencies they needed to assess.

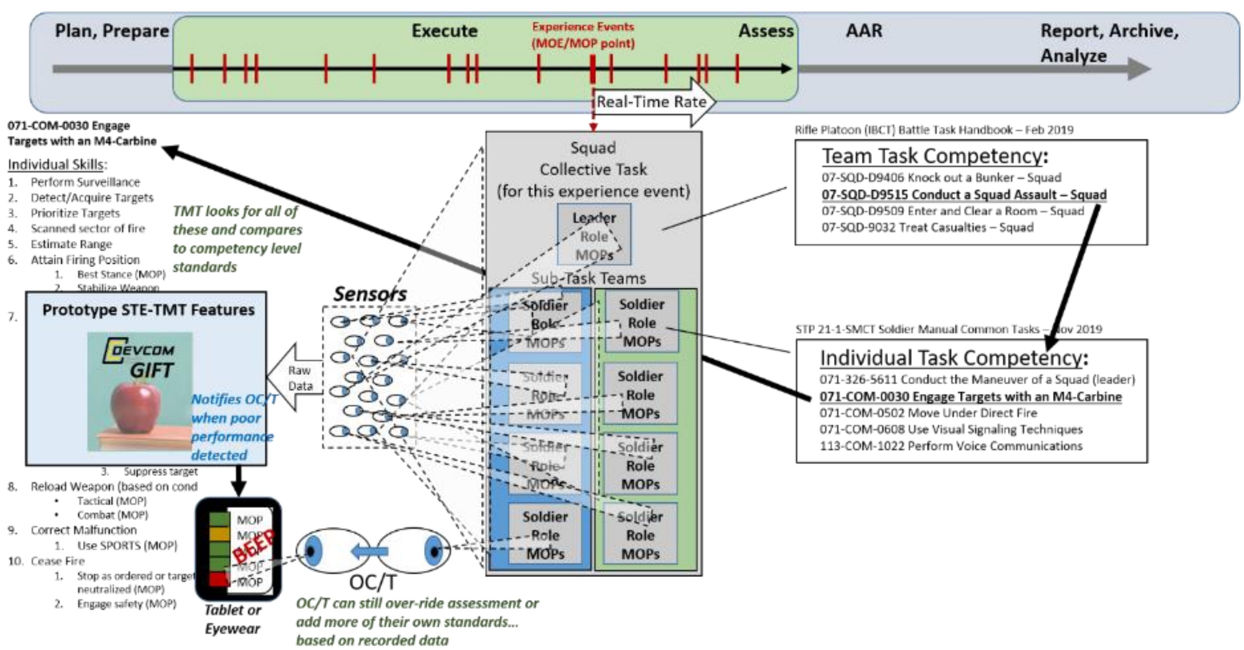

Figure 5. Changing the model of small-unit competency assessment using new user experiences, interfaces, and AI.

Even if multiple OC/Ts are assigned to assess a TSU's performance, the exponential growth of activity of several team members over time, even what multiple sets of eyes can monitor, is non-sustainable nor does it account for the natural limitations of human cognition. Instead, ML/AI, with the accumulated experiences of multiple past training sessions for the same competencies, will support one or many OC/Ts in conducting their own abductive reasoning much more effectively; it will support OC/Ts by allowing them to see what other past OC/Ts observed (through the

AI). This integrated vision of ML/AI and human OC/Ts is what will make the future TSU synthetic training model more efficient, effective and allow greater learning in less time. The GIFT architecture (noted earlier) is currently being extended to support these forms of activities by creating a human-machine Adaptive Instructional System collaboration model (Goldberg, Hoffman & Graesser, 2020). This supports a combined data-informed and observer-informed assessment model to guide performance tracking and establish supervised data sets to drive AI/ML modeling techniques.

Data Traceable Assessment, Feedback, and Assertions

As noted earlier, feedback is the source of the emotional-element that really forms learning pathways. How we make this feedback as rich and effective as possible is by providing learners the actual data of the performances they did. This not only helps learners with the memory recall process and fills in gaps where human short-term memory falls short but provides learners the *proof* they need to overcome the cognitive-dissonance and other psychological catalysts that spawn learning. The future STE will do this as part of a new version of the Army's venerable After-Action Review (AAR) process (Combined Arms Center -Training, 2013) when the OC/T and the TSU learners review and recall their performance in a combat experience they just had.

Key to this new process is the collection of raw data from the real or synthetic combat experience with sensors that are part of the soldier Kit. This will be possible through the "internet of things" that future TSU soldiers will be afforded from new visors, smart-weapons, smart-garments, smart-watches, as well as other support technology like drones and other such sensors. Initially this data will be saved, manually interpreted, graded (and labeled) against established competency levels as part of a new XR enabled AAR user-experience and user-interface. Later, this same data and labeling will be used by ML/AI algorithms to support a more automated competency assertion process using AI-based recommendations that are presented back to the trainers (and performers) with associated recorded data as evidence. This method will be presented through XR enabled points-of-view that maximize the soldier's emotional response to their performance feedback – as opposed to a more biased, short-term memory enabled discussion that current AAR and TDT protocols employ. Now the well-established processes of the critical incident technique (Flanagan, J.C., 1954) and this enhanced TDT – augmented by this new STE-TMT technology – can be executed to flesh-out and highlight TSU bad performance, and/or reinforce good performance more rapidly and efficiently than before.

The STE-TMT's use of XR based holographic technology, and collected data, will support the OC/T with visual and aural indicators to help them track the many environmental factors, behaviors, and even health and cognitive indicators happening at the same time, and all during close-combat performance. The data will be visualized with precision and in a complex symphony using automated exercise event-assessment authoring technology that would be part of a JFCDS and MSaaS based architecture like STE-TMT. This way, soldiers will be able to more precisely and efficiently "replay" why they performed outside accepted performance bands, and why they did it. In addition, this technology will identify when teamwork dimensions were occurring (or not), as well as help leaders gain insight from their decision-making outcomes or show them how their leadership made a difference to the overall outcome of an exercise. TSUs can also see how important their various roles are on a team - especially as casualties occur - and why overlapping team qualifications and self-protection/survival skills are just as critical and necessary to keep the TSUs combat effective as marksmanship and other more offensive skill-sets overly focused on today.

Experiential-Expertise Measurement and Prediction Models

As stated earlier, a key objective of TSU training is to continuously extend their combat experience which will naturally improve their combat task until reaching a level of competency deemed necessary to have *overmatch* over a potential enemy force. Once that level of competence is attained, it then must be sustained or perhaps elevated further as adversary capabilities improve or to increase the "overmatch buffer" to avoid wars in the first place. To predict and assess achievement of these needed levels, future training systems need predictive math models to help readiness decision-makers determine if a given TSU has *overmatch* and at what level.

Lessons from the recent novel COVID19 virus pandemic are instructive in how assessments and their paradata are critical to predict what may happen in the future based on math models for given situational parameters. Predicting and preparing for warfare is symbiotic but first the data must be collected, the math-models developed and the integration of all that in a (yet-to-be-developed) decision processes must occur. The way future STE based training will support the management of TSU expertise and readiness will be through math models like shown below.

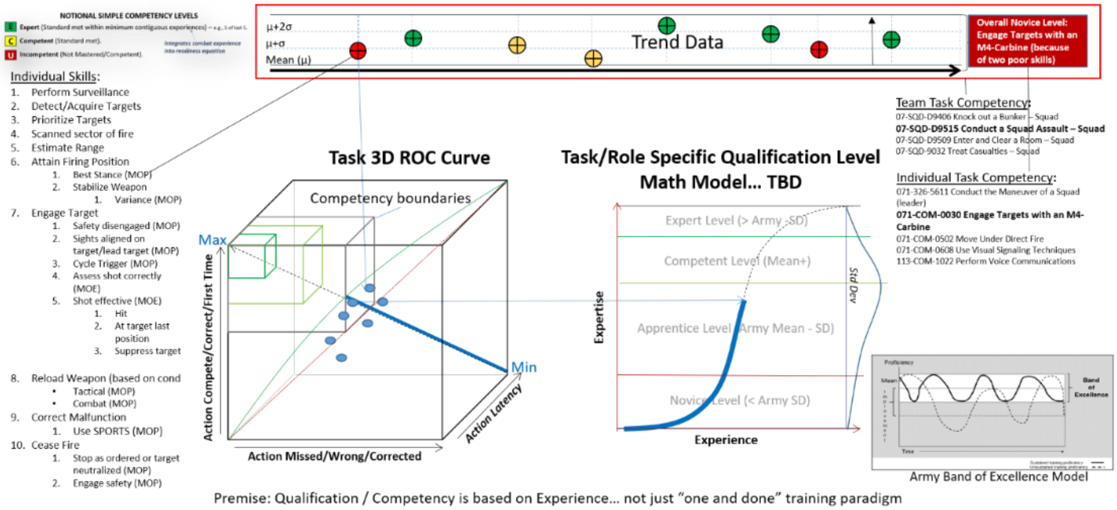

Figure 6. Experience and Expertise Measurement Models and Outcomes.

While many of the intricate performance outcomes will be of interest to the individual TSU leaders and soldiers themselves. The indicators that military managers will want to watch are the trends of their units predicted ability to performance against certain future enemy capabilities in different environments. Managers will also want to know how the training experiences invested in improves the expertise of their units, and by how much. Leaders and managers will also want to be able to *drill-down* to the source or the "why" a trend has occurred or has changed, and what area of performance (and its corresponding training) is causing it. OC/Ts will also want to see the experience background of the troops they will observe, assess and/or train so they can predict outcomes and adjust instructional strategies accordingly before they spend valuable time conducting a training session in the first place.

FUTURE TACTICAL SMALL-UNIT SYNTHETIC TRAINING POLICIES AND REQUIREMENTS

A lot of discussion so far has been focused on the technical capabilities and execution techniques the future TSU synthetic training model will need to employ but not *how* the future training model will be implemented. What is encouraging about this phase of the discussion is that the future TSU training model will not have to be much different than *how* the Army already envisions its TSUs being trained. Not only has the US Army already produced very good training frameworks that naturally enable the practice of X-learning but with future STE, it will now be easier for these frameworks to adopt all that has been discussed so far into their existing processes.

How to Implement Future Tactical Small Unit Synthetic Training Model

Warrior Tasks and Battle Drills (WTBD) are what the Army has identified as the critical training needed to enhance the soldier's readiness to fight on the battlefield (US Army STP 21-1-SMCT, 2019). Warrior tasks are individual Soldier tasks (competencies) known to be critical to combat effectiveness. Examples include weapons employment, tactical communications, urban techniques, and combat first aid. Battle drills are those team combat tasks that are likely to be assigned in future wars but are designed to build unit experiential-expertise so they can react, survive, and successfully accomplish missions' in combat situations. Examples included react to ambush, react to chemical attack, evacuate injured personnel, assault fortified positions, enter and clear rooms, and react to incoming indirect fires. As stated in Army doctrine, "WTBD increases the relevance of training to current combat requirements and enhances the rigor in training. The driving force behind the change comes from lessons learned." This means this framework already embraces the need to collect data, assess from data based on established standards but also to help commanders adapt to changes faster to new enemy practices or to changes in operational environments.

To incorporate this form of process, the future TSU training model must be a continuous and incorporate a systemic X-learning based schedule, and not just the waterfall-episodic approach described earlier. Furthermore, training exercises must be based on the latest intelligence and reconstructed operational research, so that lessons learned are transferred to the training process faster. In contrast, today's combat units or local training centers are required to create their own training exercises, as well as conducting all the necessary research that goes with it. With the advent of automated event-based assessment technology (that require sometimes days to design and refine) and other more sophisticated experiential learning capability, future TSU leaders simply will not have the time nor the expertise to build future learning exercises. They will have enough combat related technical competencies to focus on without having to also become competent in the skills learning engineers must have to properly create effective training exercises, even today. The other reason is that today, most locally created exercises are based on what a unit already knows or believes because it's easier. As such, new learning doesn't happen and lessons learned are never incorporated into training.

In addition to separating training exercise design from the TSU leader's duties, improving the access and policies of training execution is also a critical enabler for implementing the future TSU synthetic training model described earlier. One of the best practices reportedly incorporated by 3rd Special Forces Group at Fort Bragg, North Carolina is the establishment of what are referred to as "Combat Gyms" as shown in Figure 10 below.

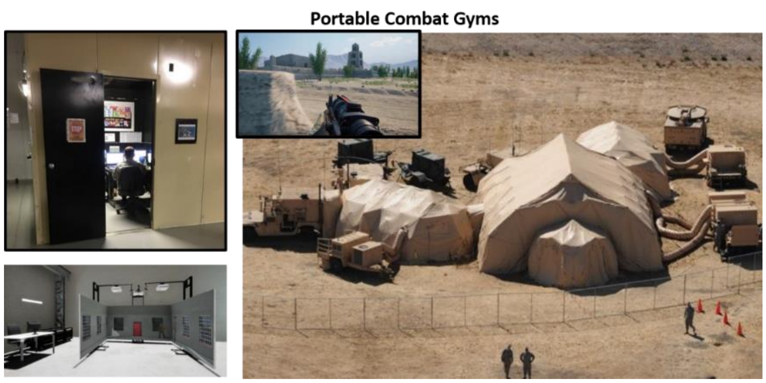

Figure 7. Future Combat Gym

This model of training stipulates that soldiers can visit these gyms at any time they wish to "work-out" combat related KSA or task-level competencies. In a more general notion, these portable home-station or even deployment site facilities would be at the Point of Need, and would be where TSU teams and soldiers can go to build both physical abilities and combat KSA, individual- and team-level tasks, on a continuous basis, and at any time of the day – instead of a linear fixed waterfall schedule. To coordinate this capability, it may be critical to execute a notional X-learning schedule as illustrated in Figure 8, and a critical new policy for the Army to promulgate and try.

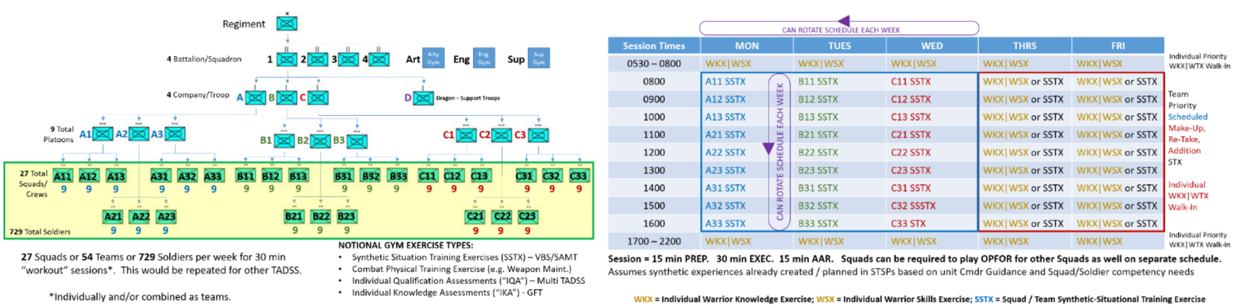

Figure 8. Notional Unit (Company/Troop) Continuous WTBD X-Learning Schedule

CONCLUSION

The future TSU synthetic training model will be a great advantage for future military readiness, given technologies like STE-TMT, and new TSU level readiness proficiency policies by the US Army and other military branches and services. Modular M&S architecture that includes AI / ML and Data Collection is what will enable flexibility in a future Synthetic Training Environment capability to rapidly adopt new combat lessons learned and new M&S technologies of the future. Competency structures will ensure the focus of future TSU training highly effective in reaching the required levels of proficiency and that assessments are evidence based and understandable to unit leaders. Allowing leaders to mitigate risk, maintaining proficiency and have greater clarity of the unit's readiness to execute assigned missions. New learning models like X-learning will be another link to the chain that pulls future TSU overmatch up, in which policies that emphasize "bloodless" combat-experience building as the key ingredient of improving future TSU performance as well as a key predictor of a TSU's readiness. Raw human performance data will be a key ingredient in the future TSU synthetic training model; it will drive critical technologies such as ML/AI that overcomes the natural limitations of human OC/Ts, and augments their ability to make better assessment and assertion decisions. To build such ML/AI, we need to collect and store more data from across the military spectrum, since data is what ML consumes to allow AI to learn and improve. How such data is collected will be a continuous process of improvement as new devices and new capabilities are developed through programs like STE and SIVT. Using data and the ML/AI it produces, will support both new assessment methods but also the critical emotional feedback element that will make readiness investments even more effective and increase both the rate and quality of learning - shortening the time it takes to develop TSU combat replacements and re-build TSU expert teams. Despite all of this advancement, it does not require the Army to change the vision of how it wants to ready its soldiers; it only requires the modification of policy and SOPs to incorporate these new technologies, capabilities, and methods to maximize the unit's potential. New best practices like Combat Gyms are necessary to facilitate training motivation and data collection. This combination of future technology, new capabilities, and training models, along with soldier-borne innovation will together build the future TSU needed to build overmatch and eliminate the "fair-fight" and help lower friendly combat casualties in future wars.

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