Combined Arms Training: Measures and Methods for a Changing World

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ABSTRACT

It is clear that the way the military prepares for combat is rapidly changing. Doctrine and mission objectives are changing at a faster rate than ever before. The operational tempo is faster than it has been in the past. Yet leadership demands a prepared military force – no performance drop-off is acceptable. In fact, we will need to discover how to train in novel ways, in novel places, on novel tasks, to meet the requirements. While technology is not the whole answer to the puzzle, it must play a part. Determining how simulation and gaming technologies can be brought to bear on readiness will be key. Measures of effectiveness that equate to readiness are also needed. Much of what is done today is subjective in nature. There needs to be an improved mix of subjective and objective measures that can be used to "roll up" readiness from the individual on up to an entire force. Identifying opportunities for simulation and gaming that really improve individual and team performance and that are deployable so that they can be used in theatre are essential to success.

We have been working with the United States Marine Corps at Twentynine Palms, California this past year on the beginning of a research program designed to (a) determine a baseline measure of how effective current training methods are towards readiness standards, (b) document the training measures and methods of team training used at 29 Palms, and (c) identify how simulation and gaming technologies can be used to enhance current training methods, and how these technologies should be integrated with conventional training. The paper will document our progress to date and will forecast what is happening next towards this important research goal that will have broad applicability beyond the Marine Corps to all NATO military training.

1.0 INTRODUCTION

The combined-arms operations are one of the core competencies in the US Marine Corps (USMC) – they represent integrated organizations of air, ground, and logistic forces under a single commander. The Combined Arms Training (CAT) is a part of the Mojave Viper training program at the Marine Corps Air-to-Ground Combat Centre (MCAGCC) in Twentynine Palms, California. It provides 'graduate-level' combined-arms training for all Marines and it is structured as a series of live-fire ground force training courses from squad and platoon to battalion level. The CAT training is followed by another block of training – the Urban Warfare Training (UWT) that completes a unit's training in the Mojave Viper program.

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Figure 1: Scenes from two Different Training Courses in Combined Arms Training.

During past year and a half we have been actively working with USMC personnel from Twentynine Palms. This collaboration was a part of the Virtual Technologies and Environments (VIRTE) program sponsored by Office of Naval Research (ONR), and was focused on different aspects of combined arms training organized for USMC units. The major thrust of our collaboration was with two USMC groups: Tactical Training Exercise Control Group (TTECG), and the Battle Simulation Center. Under the VIRTE program umbrella we engaged in two major research activities: first, we worked on determining the baseline parameters of training provided in CAT, and second, we engaged on several transfer studies focused on the effectiveness of training with virtual training simulations used in units' preparations for the CAT. Each study involved working actively with two USMC battalions. We collected invaluable information that both supported our research efforts and helped further our understanding of this domain. While we are still in the process of analyzing the data collected, we are able to extract the results of qualitative analysis and present them in this paper.

We first provide an overview of combined arms training and give the rationale as to why specific and focused types of training are needed prior to unit's coming to Twentynine Palms and participation in Mojave Viper. The specifics of our approach in conducting users studies are also detailed as possible guidance to readers who are planning to work with domain users and practitioners. We detail both studies, the baseline study and the study focused on evaluation of training effectiveness with virtual training simulations, and provide insights and lessons learned throughout this work. Finally, we discuss our findings and conclude with an overview of research areas that we plan to focus in the future as a result of the work in these studies.

2.0 COMBINED ARMS TRAINING

2.1 Crawl-Walk-Run Approach

While attending the one month long training in Twentynine Palms, each unit goes through a series of classroom events ('craw' and 'walk' stages in the training process), and they complete their training in the field with selected live fire exercises (a graduate level – 'run' stage). The support for these classes and exercises in the field is enabled by a number of professionally trained and highly experienced TTECG instructors (called 'coyotes'). They ensure everyone's safety, and they control, monitor, evaluate, teach, train, coach and direct Marines during the execution of their training missions in Mojave Viper.

2.2 Specifics of the Training Environment

Being that the number of hours and days that can be spent in live fire courses is limited, each unit as well as TTECG instructors need to make sure that this small window of opportunity is utilized most effectively and with the best possible training results achieved. There is a strong demand to make the best use of resources available to the unit in Mojave Viper, which is emphasized by the fact that most of these resources and opportunities are not available in a units' home base. They consist of the following:

- use of unique, specially designated terrain of the appropriate size to enable training in each course (exercise),
- availability of professional expertise provided by highly trained and experienced TTECG instructors,
- use of costly live ammunition, ordinance and materials,
- use of air assets not usually available to the units in their home bases,
- use of complex logistical support,
- use of specially designed training environments provided for each course: mock-up villages, trenches, mock-up mine fields, remotely controlled pop-up targets and smoke signals,
- training under challenging combat conditions: challenging and disorienting terrain, and excessive weather conditions (strong winds and sand storms, yearly temperatures ranging from below freezing up to over 120 degrees F).

Due to prohibitive costs, it may not be possible to have units spend more time in live fire exercises, even though live fire training may lead to better results. If the level of a unit's preparedness is not close to the 'run' stage (near graduate level), the resources made available to the unit in live fire will not be used most effectively because the foundation material has net yet been mastered. In such a situation it becomes imperative to invest additional effort in the units' training prior to their coming to Twentynine Palms, maximizing their chances for greater training success in the field. We also emphasize that within this domain, no training system or set of training systems is a suitable replacement for the physical nature of a live fire exercise and the complexity of that environment. Suggesting that virtual training systems are possible replacements for an entire training cycle is counterproductive and does not serve the community well. However, it is highly appropriate to use virtual training systems as a supplement to regular training or as tools to replace selected parts of that training, provided that the final goal of improved performance in the live fire exercise is achieved.

3.0 USER STUDIES

3.1 Our Approach

Our past work in collaborative projects that involved a number of partners is extensive and over time we have distilled several themes that we see as crucial to the success of these types of activities. This approach enables us to draw valuable insights from our data and observations where our conclusions are useful across multiple domains and user populations.

The themes that guide our work are:

- **Domain (expert/end) user populations**: In studies that involve specific user populations, we work predominantly with domain (expert/end) users as our source of data and information -- in this case military personnel of all services. We typically do not use surrogate or "representative" user

populations in studies. This enables us to attain a high level of relevance and to address the very needs exercised by these end users.

- **Extensive subject matter expert consultation**: In each project activity we consult heavily with a large group of subject matter experts. The majority of our students are military officers and some of our faculty have had a military career prior to their coming to NPS. This helps us quickly and clearly identify the problem space, connect ourselves with the relevant knowledgebase in the domain and address specific issues central to our study.
- **Domain practitioners as project partners**: This is probably the most important and also unique element of our approach. When working with domain practitioners and subject matter experts, we encourage and accept them in the role of project partners rather then merely occasional expert advisers whenever possible. This approach allows for much tighter collaboration and enables a mechanism for ensuring high relevance of our work and results. Additionally, a collaboration framed like this provides for direct integration of project results into the community of training providers and end users because they have taken some level of ownership of the project and process. This is extremely important to motivate the user population to adopt the final product. The researchers in the project also have the unique opportunity to benefit from the rich experience and expertise that the practitioners have acquired through their professional jobs, and this exchange of expertise may have been missed or it would be accomplished to a much lesser extent if the work was not organized in a partner relationship.
- **Two tier approach**: When engaging domain users it is important to get an acceptance (the 'buy in') on two levels. One level is represented with the leadership of the community that we work with – they need to have a clear understanding of the research goals, and be assured that the resources they invest in collaboration will be well spent. The other level of user community are the end users themselves – they need to know if and how their lives and work will be augmented with the use of systems and approaches that we suggest. They are more likely to reject solutions if those were imposed on them, and which they did not have a chance to fully accept as theirs. Some elements of grassroot approach may be very effective in assuring the support of end users, yet the support of leadership will still be needed if the goal is to work with large number of end users and do it in an organized and well structured way that clearly supports unit's training needs.
- **Extensive and long term collaboration**: In order to create high level of trust essential for a fruitful collaboration, and to ensure that the domain is well understood, one needs to spend considerable time with domain users in their work environment. We are unfortunately the frequent witnesses of situations when researchers spend insufficient amount of time observing and working with domain users, and as a result they remain on a superficial level of understanding of the domain. Very short and infrequent visits are almost sure signs that the results will be highly limited and in some cases even misleading. The phenomena and situations that are studied may look 'easy' and manageable after two hours of observation, but the real complexity may become evident only after two days of thorough analysis, interviews and observation. Additionally, a long term dedication to collaboration is another important aspect that leads towards greater success – if domain users know that the work does not happen in 'one instalment' only, but that the appropriate follow ups will be put in place, they are more likely to invest more of their work energy and have a higher level of appreciation for the collaboration.

We firmly believe that these themes, along with the nature of our institution as an educational and research organization, as well as the access that we have to the fleet as a government institution, provide significant advantages when addressing training and operational needs of the fleet in our research.

3.2 Baseline Study

3.2.1 Objectives and Goals

The baseline study was designed to benchmark the current training situation, procedures, metrics and evaluation of the overall preparedness of multiple units for collective training. The training situation that was used to acquire those insights and to evaluate a units' performance was Revised Combined Arms Exercise (RCAX) that later on was transformed into Mojave Viper. The results of this study help us describe a baseline of today's training and to establish a set of benchmarks to be used for the future training processes and products. The study also provided constructive guidance about the ways in which training simulations could assist in future training.

This study involved no direct intervention on our part and was primarily focused on collecting subjective and objective data, and our observations. The data were collected in a manner that allows us not only to acquire the final results (summative analysis) but also to have a good understanding of the process that units went through while preparing for different courses in the live fire exercise (formative analysis). We organized data collection through three sets of questionnaires. The first was administered two to three months prior to the unit's participation in RCAX. The second was administered just before the unit went to RCAX, and the third was administered immediately after RCAX. Each questionnaire took about 20 minutes to complete. We also conducted a small number of in-depth interviews with trainees (Marines), unit commanding officers, TTECG personnel, and we recorded observations and evaluations that TTECG instructors made for each course in the live fire exercise.

3.2.2 Lessons Learned

Team performance measurements: When attempting to evaluate performance of a group of individuals, especially if their performance consists of a set of actions that do not have clear-cut quantitative results assigned to them, one is confronted with several interesting problems. One is a tendency to aggregate the results to provide a unified measure of group performance. If we say that a certain unit's performance was 'average', we have very little if no understanding that would help us compare that unit with others. Two 'average' units may actually be quite different. In this situation we chose not to aggregate results but rather remain at the last level that provides information useful for further processing and consideration. The second problem is associated with using quantitative measures outside of the full context in which they were obtained. An example may be presented with measuring performance of two teams that engage in clearing the same set of rooms. Imagine that team A finishes in 10 minutes and team B in 25 minutes. Not having further details about their performance one could conclude that team A was more effective. Had we known that, for example, team A lost 60% of their personnel, and team B completed with all team members alive, we would draw very different conclusion. This line of consideration warns us to be very careful when dealing with any measure in isolation from other values collected in the same context, as that may provide misleading conclusions. Also, quantitative measures are best understood if supplemented with qualitative measures. Together they provide a full picture and enable a thorough understanding of the domain. The same consideration holds for the subjective and objective data – we need both to be able to have full insights into the domain.

Performance trends: Our observations suggest that the existence and number of performance trends exhibited by the unit, as well as unique items for a particular unit, may represent a preferable tool when evaluating the level of preparedness for a given unit in live fire training. While no unit is identical to any other, there are remarkable similarities in their performance. Beside very good performance that a unit may demonstrate, they tend to repeat some trends that are qualified as negative. As an illustration, loading weapons

while kneeling or standing while exposed is a negative trend. Our main sources of objective measurements were evaluations collected from TTECG instructors. When evaluating a unit's performance TTECG instructors will mention outstanding (good) performances, but they will primarily focus on things that need to be improved. Therefore, their evaluation will have a plethora of information related to negative trends and limited information on things that went well. This is understandable because in the limited time allotted to debrief the unit, the instructors need to provide the best guidance on where to focus further training efforts, and how to improve the overall level of readiness of that unit. The negative performance trends are a clear indication of the areas where the supplementary use of virtual training systems focused specifically on those skills may be considered. They also may point to new features, new types of training, or even new systems and lines of research that need to be introduced to help address those negative performance trends. Closely associated with this is a need for more systematic identification and documenting of negative performance trends.

Video games: according to our preliminary statistics more than 60% of Marines play video games in their free time. Given the fact that they do so on daily basis and for several hours each day, it represents potential that is waiting to be tapped. Since video games are associated with something that people enjoy doing and are very passionate about, bringing this energy and enthusiasm into the work environment through the use of such systems and tools can only benefit that work environment. Additionally, the same people will already be experts in basic skills that one would need to spend time teaching them even before the training starts (navigation and wayfinding in 3D worlds, object manipulation, remote collaboration, and similar).

Constructive integration of a set of skills: People are capable of mastering individual skills in a 'disjoint' fashion, but they experience new problems when the same skills need to be combined in a set of connected events where timing and priorities of several tasks need to be decided, and when a set of tasks may need to be concurrently performed. Our hypothesis is that if the training is presented in 'chunks', without making critical and causal connection between those 'chunks', the likelihood of experiencing problems when integrating learned knowledge and skills is higher. The design of new systems and training approaches should take this into consideration and ensure that necessary elements of skills integration are included whenever possible.

Learning of evaluators: While observing TTECG instructors in their job, we became fully aware of the uniqueness of their position and special learning process that they were going through. Being that they are not part of the units that come to Mojave Viper, their position is neutral which allows for more objective observation and evaluation, and consequently they are able to notice and comment on mistakes much easier. The learning enabled in this context carries extraordinary value, and it can be regarded as a great learning opportunity for all future unit leaders and commanders. We were told that some units do send their commanding officers to observe live fire exercises prior to the unit coming to Twentynine Palms, but this is not done on a systematic and organized basis (it is also not required). There is only anecdotal evidence about those units exhibiting a smaller number of negative performance trends, but we did not have the opportunity to look into this and confirm it in our studies. It would be interesting to see what kind of improvement in a unit's performance could be registered if commanding officers were required to spend some time with TTECG instructors, helping (shadowing) current instructors, and bringing that knowledge back to the unit. While one can argue whether this opportunity can be afforded to all units or not, it is obvious that similar learning experience can be still provided to everyone by presenting them a set of well prepared short video clips (those video clips can be made using the same virtual training systems that the trainees will use in their training). In this situation the trainees would be asked to observe, evaluate and comment on performances they just saw. Being that they are still the neutral observers (it is not their own performance they would be judging), they would have that relative distance and reduced level of pressure that is adequate for the beginning of their training. Our hypothesis is that the same trainees would be less inclined and less likely to

repeat the same mistakes that they just observed, evaluated and (perhaps even harshly) critiqued. In this context two different technologies are seen as supporting each other and enabling more effective training overall. We would like to note here that, as the training progresses and the trainees' skills mature, they should be put in situations where they need to evaluate and provide constructive critique for their own performances.

Longitudinal studies: We were eager to engage in longitudinal studies over multiple years, and to follow up the development of one unit's performance level over time. However this was not possible for two reasons: each unit changes dramatically in the course of one year. The next year it is almost a completely different unit. Along with that fact, people advance in their careers, and the position that they had last year is most likely to be different next year when they are essentially just beginning to learn more about that particular (new) position. Both reasons result with units being two different constellations of individuals in each year.

3.3 Evaluation of Training Effectiveness

3.3.1 Objectives and Goals

The goal of this study was to evaluate the initial effectiveness of the use of a virtual training system in support of training organized for the unit prior to unit's participation in Mojave Viper (trainees used those systems for the first time). We have collected data related to training organized in support of the Collective Training Standards in convoy operation training situations, and we are currently working on another study that involves training of Fire Support Teams (FiST teams). The work on both studies will provide a constructive contribution towards the program (VIRTE) mission: evaluation of the effectiveness of training simulations, defining instructional strategy matrix, training transfer, team metrics and team performance.

Our hypothesis was that the strategic use of virtual training simulations as a supplement for regular training, will bring positive impact on unit preparedness, affecting unit skill acquisition, skill transfer and retention rate, unit performance and motivation, their understanding of task complexity, and a shared sense of belonging to the organized group of individuals working together. Currently we have only anecdotal evidence given by the practitioners about the positive impact of this training tool, and our studies were designed to help us establish a solid basis to exercise scientific rigor in drawing conclusions.

Both studies involve a training intervention that consisted of supplementary use of virtual training systems in conjunction with the unit's regular training. The systems used in the study with convoy operations were a desktop training system -- Virtual Battlefield Simulation (VBS [2] by Coalescent Technologies Co., Figure 2 (a)) -- and immersive 'wrap-around' CAVE-like system -- Virtual Combat Convoy Trainer (VCCT [3] by Lockheed Martin and FATS Inc., Figure 2 (b)). The system we plan to use in the second study with FiST teams was designed and implemented by the VIRTE team. The core of this training environment consists of Forward Observer (FO) [1] and Forward Air Controller (FAC) PC training simulations initially built by MOVES students and staff.

Figure 2: (a) Training using VBS System, and (b) Training using VCCT System.

3.3.2 Lessons Learned: Perceived Trends in Using Virtual Training Systems

We had the opportunity to spend considerable time observing the Revised Combined–arms Exercise (RCAX) and Mojave Viper as well as training organized with VBS and VCCT virtual training systems, and our preliminary findings confirm what we initially expected. The issues of availability of good training simulations cannot be treated separately from the issues of availability of equally good training approaches and methodologies. The two are tightly and critically connected, and together they predict the success of training in virtual training systems. In other words, no variety of virtual training systems, no matter how feature rich they may be, will have a great impact unless we ensure that people use them in a well structured process and framework -- the right people receive the right training, at the right time, for the right period of time, with well trained instructors, and with the right training methodologies that fully support the training objectives and associated operational needs.

To illustrate our point we will describe the most common trends that we identified concerning the use of virtual training systems:

- **Short exposure to the training system**: The total time that the trainees spend using virtual training systems is insufficient. The usual approach is to have one 3-4 hour long 'one-shot' training session. That number of hours is not sufficient to acquire and practice a complex set of individual and team skills.
- **One-time exposure only**: Trainees receive training in one block of several hours only, with no possibility (usually no time in their schedule) to use training systems again. There is no repeated exposure to a particular training system and no opportunity to do proper solidification and corrections of their skill-set.
- **Timing not appropriate**: Trainees receive training either long before training in a live fire exercise (or some other situation when they need to use those skills) or right before such exercise. In the case of the former, the retention rate of perishable skills may be too short to be able to retain the necessary level of the same skills learned long ago in training simulations. In the case of latter, there is not enough time to reflect and do proper improvement and corrections of skills if that may be needed.
- **Mastering individual skills first**: Team training is frequently organized with no special care given to mastering individual skills prior to that. Ideally, the initial skill level of each trainee should be evaluated and proper individual training provided before they engage in team training. Quite often it is

important to incorporate additional prep-classes to bring everyone's skill level to a higher (necessary) degree, and maximize chances for best training results when using virtual training simulations.

- **Disconnect between training systems and (right) users of those systems**: Trainees who end up using virtual training systems are not necessarily the Military Occupation Specialties (MOSs) that should receive that particular training. It may well happen that people who received training were the ones who were simply available at the time.
- **Training or 'fun'?**: Some trainees see this kind of training as 'gaming' (i.e. fun) and may not approach it with the right attitude where they can learn from the experience.
- **Need for training relevance**: There may not be very tight and regularly updated connection between the training provided in simulations and the one in the live fire exercise.
- **Need to support the same training objectives**: Centers providing this type of training may have insufficient understanding of all training procedures and important training parameters established and observed by the TTECG.
- **Need for specially trained instructors**: Instructors that organize training in training simulations are either military personnel or contractors (a large majority of them are former military personnel). Typically, neither has received formal training to be an instructor in this kind of training environment. (and it is indeed a different training environment from what they are used to in a more traditional training setup and for which they are well versed.) Therefore appropriate training is very much needed. Best 'guesses' as to how such training should be organized is not sufficient if the goal is to use resources most effectively and have highly trained military forces.
- **Need for solid training approaches and schedules**: There is a lack of well scripted and documented robust training routines and methodologies. There are too many 'on the fly' and 'ad hoc' approaches where each instructor has his own individual way of training.
- **Accountability**: There is no identified accountability for training results achieved in these training systems. We are not sure how this could be remedied, but one way of handling it would be to use motivation and peer-competitions as an alternative tool to maximize potential that such systems provide.
- **System support for AAR**: The systems do not provide good information for After Action Reviews (AAR) or if they do, it is not used in a systematic way. After the training session, unit leaders do perform AAR but it is based purely on their observation and is rarely backed with the data recorded by the system.
- **System rigidity**: A large majority of systems are very rigid in the sense that they do not support user-specified scenarios, scripts, use of terrains, terrain features, weapon systems, and objects of users' choice.

A global trend that we see in training community is using approaches and systems that may be sufficient and good for categories of users that fall into the groups of innovators and early adopters – those users do not need a great deal of convincing, the systems they use do not need to be perfected and they can manage with little if no additional structure added to training. However, as these groups are extremely small in their number, the objective of training community must remain on creating technologies and approaches that will work successfully with large number of people – the early and late majority of users [4]. These groups need far more structure, support and motivation in training cycle, and the systems they use need to be adjusted to their knowledge and skill levels.

4.0 DISCUSSION

4.1 Augmenting Virtual Training Systems with Lessons From the Field

Training organized in a live fire exercise reflects professional and corporate knowledge acquired over a large number of years, and as such represents an ample resource when defining parameters of a good (ideal) training environment. The observed runs on each training course offered the following insights that could be used to augment current virtual training systems.

Dynamically responsive systems: The performance of each unit is carefully monitored by TTECG instructors. They first act as independent observers and let the unit wrestle with the problem. If the unit is capable of the current level of difficulty, the instructors usually add new elements and extend training objectives to match the unit's performance. If, however, the unit is observed to experience difficulties, they receive proper guidance and coaching, and in some cases the overall level of difficulty of that training run can be adequately reduced to ensure that unit has enough time to accomplish (other) most important training objectives. The current knowledge of the unit is judged and evaluated on the spot (instructors know nothing about the unit's level of preparedness prior to unit's coming to Twentynine Palms!), and both coaching and intervention are adjusted to meet that knowledge and skill level.

When we try to translate this complex process to the domain of virtual training systems, one can imagine that some functionality could be accomplished by having an automated training and knowledge management system. This system would provide some level of expert guidance on the fly. Yet, we still recognize that such highly sophisticated levels of instructor intervention may well never be achieved with automated systems, and therefore if our goal is to achieve the most effective training, it is appropriate to recognize and distinguish the tasks and training interventions that can be automated and the tasks that are best served by having human expert intervention in the loop. Enforcing automated support for parameters that cannot be effectively supported is seen as counterproductive. It may also give us a false sense that we achieved something by 'engaging' the system to take care of it, while, at the same time, that may be quite far from the truth.

Automated AAR and continuous, organic system adaptation: There are two types of internal debriefings done after each training run in live fire training. The 'coyotes-to-coyotes' debriefing, Figure 3 (a), consists of reports of all field instructors given to the main instructor who compiles everyone's comments into the information that will be presented to the unit later on. Ideally, the virtual training system should provide exactly the same information: both a summary of the overall unit's performance as well as information that reflects the way in which each part of the training run was accomplished. A second part of 'coyotes' debriefing is related to the internal affairs and performance of all instructors in the field. This is an opportunity for the group to discuss and critique approaches and strategies that did and did not work well, and to identify what changes (if any) should be introduced for the same course the next time. As a result, no two runs of the same course are identical - they grow organically and at any given time reflect the level of understanding that instructors have acquired for a certain training situation. We see this as a great example of "innovation in action", an ability and readiness to change one's acting and parameters of working environment as soon as a better and more effective solution is perceived as needed. While it is difficult to imagine that one virtual training system could have this level of flexibility and be able to change from one training session to the very next, it is still possible to introduce some elements through the concepts of user-defined scenarios and scripts that, to some extent, may provide a much needed level of innovation in successive training sessions. This becomes an imperative if the same training system is to be used multiple times for training the same group of individuals.

Expert guidance for follow up training: After each training run TTECG instructors conduct a detailed debriefing with the unit ('coyotes-to-unit' debriefing, Figure 3 (b)), where they report about different aspects of the unit's performance. At the end of that debriefing session the main instructor provides an account and critique for the entire training run. This debriefing is always combined with suggestions for improvements that can be readily used to plan follow-up training actions. Bringing this to the domain of virtual training systems, the effective approach would be to provide the same level of consideration and advice, making sure that the group has a clear understanding of what kind of skills they need to improve and, equally important, advice on how to go about it.

Figure 3: (a) Internal Debriefing ('Coyotes-to-Coyotes'), and (b) Unit Debriefing ('Coyotes-to-Unit').

Systems and approaches that train for the values highly regarded by domain users: While observing training runs in Mojave Viper, we identified a number of general skills that are highly regarded by domain practitioners:

- be able to conduct thorough mission planning,
- have high awareness of what each person needs to know and do and how it affects others,
- have rigor in execution when needed but also allow for flexibility when that is needed,
- be able to change the plan on the fly,
- be able to handle unexpected situations, and
- be able to 'parallel process' and work on preparing the next missing while still executing the current mission.

Training systems and training approaches that would provide some elements of this would be offering considerable contribution towards producing 'always ready' and 'always maximally ready' forces.

All these examples refer to possible augmentations of virtual training systems, but the same lessons are equally relevant and can be applied to any training (learning) system.

5.0 FUTURE WORK

There are a number of questions that we would like to address in this line of research, and we mentioned some of them in Sections 3. and 4. Here we list other interesting research issues:

- What is the effectiveness of training simulations that we use today and what are the appropriate measures?
- How well do we incorporate them into the training process?
- Do we use the right technologies, the right training approaches, at the right times, for the right audience and for the right purposes?
- What kind of technologies and training approaches can be used to support and to enhance team leadership skills? What do we need to provide to strengthen that role? [5]
- What (minimal) investments with different technologies can have the greatest impact on learning, training and motivation?
- Can we use appropriate combinations of different technologies and learning/training methodologies so that they encompass learning styles exercised by the majority of trainees?
- How can we address issues of Human System Integration (HSI) so that these training systems respond to perceived training needs, and the results of that training are fed back to the system design (and consequently 'close the loop')?
- What type of field instrumentation can be designed to support HSI concepts and at the same time produce valuable resources for training?

As of now, the research community does not have good answers for these questions, especially when we apply them to training situations that deal with collective performance.

We see our future research efforts continuing down the line of working with domain users and domain practitioners, drawing from our experiences from applied field research, and bringing them into the domain of basic research. The constant intermingling and tight connection between applied and basic research is seen as the best approach to ensure that the investments made in this field will be highly relevant and addressed with priorities perceived in the domain.

6.0 CONCLUSION

In this paper we provided a snapshot of our reflections and up-to-date results from research that we conducted in collaboration with USMC and supported by ONR. A complete analysis that integrates quantitative and qualitative results gathered so far is planned to be completed this year. The work on second transfer study with FiST team training will be finished in 2007. Together, those results will provide much better understanding of the applicability of training interventions with the means of virtual training systems, how to measure the effectiveness of that training, and help us define necessary guidelines for a large scale and a long term deployment of those training environments in military settings.

The virtual training systems and training methodologies that provide ideal support for combined arms training, and for that matter any training in military domain, need to integrate several important aspects discussed in more details in this paper. They need to harness invaluable experiences from the field training and deploy

most effective techniques into technology-supported training systems, they should be a result of close collaborations with domain users and practitioners, and the additional efforts need to be invested so that systems and training approaches are designed and developed specifically for the large number of users (early and late majority categories of users). It also needs to become a matter of regular practice that training systems will not be delivered and deployed without providing a comprehensive guidance on the best training approaches designed specifically for that system for intended audience – a whole 'package' needs to be made available to the users if the maximal return on investment is expected and needed.

As the military doctrine and mission objectives are changing at a faster rate than ever before, there is a growing need to train in novel ways, in novel places, under the novel conditions and on novel tasks. The virtual training simulations, if used in an appropriate framework, can be seen as a powerful tool in ensuring that those capabilities are provided in the training domain, and that the leadership demands for an always and maximally prepared military force are fully supported.

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