DEFINING THE USER'S TRAINING TECHNOLOGY NEEDS: THE ARMY'S EXPERIENCE

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ABSTRACT

User acceptability of new technology is directly related to the degree to which the technology satisfies the user's needs. The salience of the relationship between user needs and user acceptability is underscored by the tenets of Total Quality Management (TQM). According to TQM philosophy, the technology user is defined as the *customer* and the appropriate role of the research and development (R&D) community is to satisfy customer needs. But, how knowledgeable is the training technology user of his own needs? Can trainers influence the course of technology development to maximize gains from their technology investment?

Conceptually, success in this endeavor requires the training technology user to have a strategic vision of where training is going in the next 5-10-20 years. The vision needs to be translated into technology requirements for the near-, mid-, and long-term. Finally, the requirements need to be communicated to the R&D community so work is focused on the identified goals.

The U.S. Army Training and Doctrine Command (TRADOC) has an effort underway to identify, prioritize, and communicate the Army training community's science and technology (S&T) requirements to the R&D community. In this paper, we discuss some of our experiences setting up this management process, interfacing with the R&D community and lessons learned. Clearly, the process requires communication between the users/customers and researchers to clarify requirements and identify useful directions for research. In addition, it is important to form alliances with users from other services, commands, and agencies. Lessons learned from our experiences so far indicate users need to be smart about what they need, be smart about science, work together, and be proactive in order to effectively manage technological change.

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Imagine the world of the 21st century where a reserve component soldier in his Montana living room prepares for his first mission in a trouble spot half-way around the world. He is immersed in a virtual environment populated by computer-generated enemy forces operating under their current doctrine. Virtual crew-members interact with him as they traverse along terrain that accurately matches the anticipated location of the mission. He experiences the sights and sounds of the mission and feels the adrenaline racing though his body. He encounters difficulties but has an opportunity to react and test a variety of responses in the safety of his home. Evaluation protocols verify performance success so we are confident training has made him a seasoned soldier who is ready to face the challenges ahead.

CAN WE GET THERE FROM HERE?

Managing change is a phrase frequently heard among Army trainers today. The proliferation of new training technologies is one area where change is occurring at an astounding rate. One way the U.S. Army Training and Doctrine Command (TRADOC) is attempting to manage technological change in Army training is through the Training Research and Development Action Plan (TRADAP). This paper describes the rationale behind TRADAP and some lessons we have learned from initiating a management process to guide technology toward our goal---providing high quality training to soldiers in the near- and far-term

The mission of TRADOC is not only to train soldiers and leaders but to serve the function of "architect of the future." In its role as architect of the future, TRADOC writes the Army's warfighting doctrine and defines battlefield requirements for the future battlefield. TRADOC looks 5-10-20 years ahead to create as accurate a vision of the future state of the world as possible and define the doctrine, training, leadership, organization, materiel, and soldier requirements we will need for the Army to be prepared for contingencies in that future world. It is in this capacity that TRADOC has the primary role of interfacing with the research and development (R&D) community. TRADOC serves as the customer's representative by defining requirements and working closely with researchers to bring needed technologies to the ultimate customer, the soldier.

As training becomes increasingly reliant on high-tech methods, trainers see that they have an even greater stake in guiding the course of science and technology (S&T) investments to ensure that future training requirements are fully supported by R&D. Twenty years ago the Army training system relied primarily on training methods such as platform instruction in school houses, instructor demonstrations, practical exercises, training manuals, and field exercises. While these methods are still the mainstay of the current Army training system, we are increasingly transitioning to so-called high-tech training methods such as computer-based training, networked interactive simulators, and video-teletraining.

Many of the elements of the Army's future training strategies are embodied in the hypothetical opening scenario: training that is safe, realistic, accessible, cost-effective, environmentally sensitive, and versatile. These future training requirements present challenges at the same time advances in technology present tremendous opportunities to meet those challenges. The nature of training is likely to undergo a profound metamorphosis.

The potential for such changes raises a number of questions. How can Army trainers insure limited R&D dollars are spent on only the most essential identified needs? In what areas can we leverage training technologies from the private sector and on what areas should we target Army resources? How can we insure efficient transfer of new ideas and products to the user so important and costly discoveries are not "left on the shelf" where they will not benefit the soldier?

MANAGING TECHNOLOGY IS A MANAGEMENT ISSUE

Questions such as these are not unique to the Army or Army trainers. There are many academic and industry articles published that address these management issues. In this era of *re-engineering* and *reinventing government,* ideas on the management of technology in the market-oriented private sector may serve as a *model to bring economies and efficiencies to* federal government. In his 1991 article, Marc Hequet describes the relatively new field of "management of technology." The essence of the management of technology is bringing together managers, engineers, and scientists to reach a common understanding of their strategic vision, constraints, and technologies' potential. It should not be a revolutionary idea, but too often management and researchers have functioned independently of each other. Initiating interactions between managers and researchers to manage technology are mutually beneficial. An educated management can better plan for the future and when researchers understand that vision, the relevance of their work is enhanced.

TOTAL QUALITY MANAGEMENT OF TECHNOLOGY

To manage the proliferation of new technologies a number of writers suggest applying the Total Quality Management (TQM) philosophy. The language of TQM has permeated our culture in recent years, perhaps to the point of overuse. However, regardless of fad or fashion, themes of quality and customer focus are enduring. For example, Philip Francis (1992) effectively argues that the basic tenets of TQM can be applied to the management of R&D investments to make them more productive. At the heart of this perspective is the focus on the technology user as the customer. By understanding the customer's needs, the research investment can be focused on meeting those needs. Assumptions and guesses about customer needs must be replaced by direct knowledge based on close interaction.

This same focus on the customer is seen as the critical factor that translates into successful technology transfer. Frequently, the R&D community is separated from the users--the ultimate beneficiaries of their discoveries. Researchers tend to "throw their product over the wall and hope someone will catch it" (Wolff, 1989). Michael Wolff describes the key steps of successful technology transfer as beginning with user involvement up front. Rather than discovering you have a "solution looking for a problem," Wolff recommends *active interactions between users and* developers to explore actual problems, validate suspected needs, and educate users on what the new technology can do. From the early idea exchanges, user participation is needed at each step of the process (identify applications, package for user accessibility, train, and follow-up) to insure successful technology transfer.

TRAINING R&D ACTION PLAN

With the understanding that the Army training community needed to undertake a program to manage technological change systematically we adopted some of the prevailing private sector ideas in the development of TRADAP. Among these are creating a shared vision between the R&D and customer communities, engaging in active ongoing interactions, and following through to ensure successful technology transfer.

The purpose of the TRADAP is to ensure that efforts by the R&D community will enable TRADOC to build the essential technological foundation for mid-to-long range Army training requirements. The key activities associated *with the plan so far are listed below.*

1. Developed a prioritized list of 65 training technologies requiring research.

2. Met with Army R&D agencies to promote training research interests.

3. With aid of R&D agencies conducted technology assessment to determine status of identified research questions.

4. Initiated cooperative research endeavors with sister services.

5. Presented research requirements to industry.

6. Co-hosted two conferences on emerging training technologies.

7. Took steps to join with TRADOC combat development community to prioritize overall Army Science and Technology Objectives.

8. Explored organizational issues related to technology transfer and proposed organizational changes to facilitate effective technology transfer.

LESSONS LEARNED

Throughout the two year period of TRADAP development and execution we have learned a number of lessons that may be instructive to others who want to manage technological change and become smarter customers for the technologies that will shape their future. Thinking back over the chronology of TRADAP events certain accomplishments stand out as keenly important to the overall success of our S&T planning effort. What follows are recommendations for important steps to take and issues to consider in development of customer-based S&T planning efforts--recommendations derived from our experiences in trying to launch TRADAP successfully.

Lesson 1: Make S&T Planning Part of the Organization's Strategic Planning Process

On the surface it may seem obvious that organizations should consider S&T needs as they define future goals, missions and requirements. However, for the TRADOC training community this hasn't always taken place. Although some S&T needs have been identified by TRADOC, some have been identified by the R&D community, and some future S&T needs associated with future plans may not have been identified at all. Our TRADAP work has reinforced our belief that customers routinely need to consider major near-, mid- and long-term future organizational initiatives in terms of the underlying S&T requirements associated with each. We have found that even a very general consideration of S&T requirements provides an adequate starting point for discussions between the customer and the R&D community about the directions for future research. Our experience has also shown that in so far as the customer is able to present S&T needs clearly in the context of specific future organizational requirements the S&T needs are better understood and accepted by the R&D community.

Six of the key future directions for Army training, derived from TRADOC strategic planning documents, are listed in Table 1. There are numerous drivers for these changes including resource, environmental and safety constraints on large scale field exercises, the change from a threat to a contingency based Army mission, the high-technology battlefield, the move to consolidate some Army occupations, and the generally increasing complexity and difficulty of the jobs of soldiers and their leaders. Each of these factors has salient implications for the future of Army training and for the S&T advancements that will be needed to support training. Table 1 also presents a few example S&T areas TRADOC has targeted for development over the next 5-20 years. Note that each S&T area is directly related to one or more of the future training requirements.

Lesson 2: Make S&T Requirements Explicit

Identify S&T needs. One of the most difficult challenges facing the R&D customer is translating future mission requirements into enabling S&T developments needed to support those requirements. What does the Army's future need for realistic training that is environmentally sensitive, safe and accessible tell us about what, if anything, the research community must be doing today in the laboratory? In our experience, the surest way to answer that question is to open a dialogue between the customer's own experts in a given future requirement and the scientists

EXAMPLES OF TRAINING TECHNOLOGIES ASSOCIATED WITH FUTURE TRAINING REQUIREMENTS

Future Training Requirements	Key Training Technologies
• Provide accessible, cost-effective training that is environmentally sensitive, safe, versatile and realistic.	• Virtual reality • Knowledge of minimum essential simulator fidelity requirements that result in training transfer • Reconfigurable simulators
• Train leadership skills appropriate for any event over the range of military operations.	• Knowledge of complex decision making • Speech recognition technology • Methods to measure and enhance leadership performance
• Prepare leaders and soldiers to be adaptable and innovative.	• Artificially intelligent/expert system performance support aids • Training techniques to prevent/ameliorate negative effects of stress on individual and collective performance
• Train for contingency missions.	• Multiple scenario generation • Knowledge of how to best design, develop, and deliver "just-in-time" training • Collective performance measurement techniques
• Promote joint, combined, interagency perspective in training.	• Training and performance support aids for effective communications between joint, combined, or interagency forces • Joint service combat simulation integration • Determine organizational changes necessary to facilitate inter-organizational cooperation
• Modernize the training development and training delivery system.	• Development of training development expert systems • Knowledge regarding implementation and feasibility issues for various training media • Knowledge of effective learner preparation techniques

Table 1

the R&D community with the most expertise and interest in that topic.

It is essential that the customer bring at least general descriptions of future requirements to the table for discussions with the scientific community. If at all possible, the customer should also provide a list of best guesses as to research needed in the S&T areas supporting each requirement. This latter point is somewhat controversial in that some argue that defining research goals should be the sole province of the R&D community. However, our experience has been that thinking through the S&T associated with specific future goals not only makes us a better informed customer of R&D it helps keep us more involved with and smarter about the technologies that we ultimately must transfer to use within our own system. Further, we have found that the more specific we are in our thinking the more fruitful are our discussions with the scientific community. Cases in point have been TRADOC's two successful technology conferences co-sponsored with Army Research Office (on Virtual Reality Technology and Training, and Speech Recognition Technology and Training). At both Conferences trainers sat down with scientists to discuss future training and related S&T needs in these broad technology areas. The outcomes provided some clear guidance for future research in these areas (see Table 2).

Some of the Research Needed to Support Development of Virtual Reality Applications to Army Training
1. Visual display systems
2. Position sensing
3. Haptic interfaces
4. Software to create virtual worlds
5. Auditory displays
6. 3-D real-time interactive graphics
7. Behavioral representation
8. Human interface issues such as simulator sickness
9. Training transfer requirements
10. Speech recognition interfaces

Table 2

Establish S&T Priorities. Another facet of our TRADAP work has been establishing training S&T priorities from the customer perspective. This step can be taken once the customer has initially identified S&T research areas needed to support future requirements. The step is needed because it tells the R&D community what S&T the customer considers most important and where to focus scarce R&D resources. Table 3 presents a list of TRADOC's top 10 training S&T priorities based on rankings provided by key representatives of TRADOC's training and combat developments communities. We provided raters some criteria to consider in ranking research areas (e.g. likely payoff of research to Army training) and found that TRADOC staff were easily able to do the rank ordering. We were also pleased to find some good consistency between groups of raters (i.e. trainers and combat developers) on general areas of research considered most and least important. After all was said and done we felt relatively confident that many of the most important research issues had made it into the top of our list of priorities.

Narrow the Focus to Under-researched Technologies. Once S&T needs have been identified and priorities established a logical next step is to crosswalk S&T needs with research projects completed, on-going or planned by the R&D agencies. Our approach was to review research programs of key training R&D agencies and match up programs with our identified S&T needs. The creation of a database to sort R&D projects by our S&T requirements greatly facilitated our efforts. Once the crosswalk was completed we were pleased to find that the majority of S&T needs were met partially or wholly by on-going or recently completed research. In discussions with the R&D agencies about their ongoing projects the opportunities for technology transfer became evident and those areas in which little or no research had been done became the focus of our efforts to influence future R&D plans. An unexpected spin-off of this crosswalk was our ability as a customer to advocate for continued funding of research programs which our independent review had established as clearly meeting our needs.

TRADOC's Training R&D Priorities
1. Virtual Reality
2. Dynamic environment (terrain and atmosphere)
3. Embedded Training
4. Knowledge of fidelity requirements for training aids, devices, simulators and simulations
5. Combat development-training simulations
6. Simulation, integration, standardization
7. Reconfigurable simulator
8. Knowledge of skill decay for collective tasks
9. Effective technologies for training groups
10. Decision support technology

Table 3

Conduct Technology Assessment. Obviously, not every future initiative will require a foundation of new scientific knowledge or advanced technology. For example, one of TRADOC's near to mid-term plans is to explore cost-effective applications of distance learning technologies (e.g. video-teletraining) to the distribution of training to

Reserve Component units. Formative program evaluation and feasibility studies may be needed to prepare for this future change but much, if not all, of the actual R&D work on the required distance learning technologies has already been done. This example points out why technology assessment, determining the "state-of-the-art" for any given S&T area, is a crucial aspect of a customer's S&T planning process. If we can best meet a future requirement by using a mature "on-the-shelf" technology then the organization can focus energy on technology transfer and eliminate the often costly and time consuming R&D step. If the necessary S&T work has not been done then that must be where the initial emphasis is placed. We found that the R&D agencies and technologists within academia, industry and the Army's training community are a willing and helpful source of expertise to TRADOC for training technology assessment.

Lesson 3: Plan for Technology Transfer

Identify and involve customer sponsors. Of course the real payoff to the customer for good S&T planning is the availability of the new scientific information or technology advancements to upgrade operations--improve the quality of products, make processes more effective in meeting requirements, save resources by operating more efficiently, and avoid costs associated with outmoded products and practices. To reap this return-on-investment in S&T research the customer must actively participate in guiding and monitoring the S&T research from inception to completion.

Once the customer has identified and communicated top priority S&T research needs to the R&D community, the customer must identify the best customer representative(s) (i.e., research sponsor) to work each project with the researchers. Responsibilities of the sponsor will include at least: 1) working with the R&D agency to specify goals, objectives and expected outcomes for the research, 2) participation in periodic, regular reviews of research progress, 3) providing support and advocacy, if needed, for continued funding of the R&D project, and 4) initiating processes necessary for transfer of the technology to the prototype evaluation or feasibility study stage or direct integration into the system. Integration into the system may involve the sponsoring office in assisting with the rewrite of organizational guidance or policy governing operations (e.g. to integrate new scientific knowledge), development of training or job aids for users of the new technology, and obtaining funding needed to integrate new technologies across the system. Our experience suggests that the level of customer effort required to pinpoint S&T research needs is a small fraction of what customers must expend to transfer technology developments successfully. Yet it is easy for this crucial aspect of S&T planning to be neglected.

Gauge Organizational Commitment. We do not mean to suggest that sponsors can or should work alone to promote technology without the full involvement and support of their organization and its leadership. Rather, the orderly transfer of technologies needs to be an organizational imperative--a fully sanctioned and resourced aspect of the organization's mission and a recognized part of the organization's continuous quality improvement program. Our experience suggests that organizations, particularly those in resource constrained environments, are often so heavily involved in maintaining the current system that it can be difficult for them to put organizational resources behind future planning. Our recommendation is that before an R&D customer begins S&T planning they give full consideration to their organization's ability to plan adequately for and take the necessary steps to assimilate new S&T. If the commitment isn't there then the timing may not be right to assess S&T requirements.

Lesson 4: Form Partnerships With Other R&D Customers

One of the most fruitful strategies for us in development and execution of TRADAP has been aligning our efforts with those of other organizations with similar S&T planning goals. For example, TRADAP has been able to piggyback on the S&T planning and execution mechanisms developed by TRADOC's Battle Labs. The Battle Labs are actively involved in identifying TRADOC's S&T requirements associated with future battlefield operational capabilities requirements. Battle Labs have made great strides in developing processes for directly influencing the Army's S&T agenda and more generally communicating TRADOC's R&D interests. We have

successfully joined TRADAP efforts with those of the Battle Labs in a number of areas including participation in the Battle Labs' yearly review of Army Science and Technology Objectives and participation in solicitations for industry science and technology developments. Another type of successful partnership for TRADAP has been joining with other organizations to pursue funding for S&T projects of mutual interest. For example, TRADOC is a participant in a Marine Corps led project to develop enabling simulation and virtual reality technologies for future training of military operations in an urban environment. We urge S&T customers to seek other customers to work with to develop effective strategies for interaction with the R&D community and to join with them to advocate for research in areas of mutual concern.

CONCLUSION

When we imagine that future world in which a soldier trains in a virtual environment we must keep one question in the forefront of our minds--How do we get from here to there? How do we achieve that envisioned end state, whatever it is? Our experience has led us to believe that a large part of the answer is active S&T planning by the organization responsible for creating that future state---the S&T customer. It is the customer who must set in motion and direct the series of events that will produce the required technological capability when its needed. This voyage to the future is far too important to leave the navigation to chance.

In this paper we have shared some of our perspectives on and lessons learned from experiences as a customer doing S&T planning. The experience has reinforced many of our beliefs about the value of organizations' attempting to manage technological change, the critical need for effective technology transfer, the importance of identifying S&T requirements associated with future plans, and the value of collaborating with other customer organizations in working S&T issues. We have also been impressed with how difficult it is, in terms of the time available, to pull in all the good S&T research ideas from the many knowledgeable and creative thinkers in our organization and how quickly future plans, future technologies, and hence S&T needs change. We have learned to our dismay that only a small fraction of the Army's R&D funding (about 2%) is devoted to research on the behavioral science issues of import to training, and that the White House has identified the lack of training and education R&D funding as a critical problem in this country. Perhaps most significantly, we have gained important new insights into how S&T advancements can potentially contribute to an exciting future for Army training. We recommend the S&T planning process to other customers as a means of gaining these insights and moving toward better management of technological change.

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