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A Possible Future for Military Training

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A Training Story

One effective training technique is to start with a "Story to Set Context." Here is mine.

Imagine, 10 years from now, the Ready Room in an aircraft carrier, which is rolling gently in the swell of the open sea late one night. The dimly lit theater-like compartment looks little different from what a ready room looks like today. Nor have the carrier's principal aircraft changed much externally from those of 10 years before. There are, of course, new electronics and modified weapons but something else makes these aircraft much more effective then they were in 2002. Something is different about the aircraft's pilot's behavior.

A bored duty pilot turns to a personal computer in the corner and turns it on. However, instead of starting the 2013 equivalent of Doom, the pilot checks into *DARWARS*: a continuously available training war – the legacy of DARPA's Training Superiority Program. The pilot tells it "I want to train." A low cost eye tracker recognizes her. The system reviews its records and says, "You didn't read your last after action review." It displays a draft of the report and, tracking the pilot's eyes as she reads, *DARWARS* points out, "You didn't look at paragraph three." Then, observing a change in skin conductivity as the pilot moves the cursor, the training system concludes that she didn't like that paragraph. It asks why. The essence of the pilot's concern is agreed upon between the computer and the pilot and a message is automatically sent to an air warfare training bulletin board to be discussed and, perhaps incorporated into a new training scenario.

The local *DARWARS* engine on the laptop computer asks if the pilot wants any others to join the mission with her. She calls around and finds two other pilots still awake enough to participate. They turn on their computers in their staterooms and are quickly linked to the pilot in the ready room. In order to make a four-"ship" formation for the mission, the system creates an avatar of one additional pilot and aircraft.

Meanwhile, a remote autonomous *DARWARS* manager looks for the right place in the right training war to give the three pilots the specific refresher instruction they need. It notes a soldier in Fort Hood who is sitting in front of *his* personal computer practicing his language skills by talking to an avatar of an indigenous commander in a tactical subset of Pashto. The soldier is coordinating a precision attack by long-range bombers to support the commander's impending cavalry charge. The bomber crew, sitting in front of their own computers or personal digital assistants in a hanger on their own airbase, have just told *DARWARS* that they need to quit for lunch. They are told that a four-ship tactical aircraft formation will soon relieve them on station. They inform the soldier.

Back on the carrier, after a short session of planning and a mission briefing from a computer-generated operations officer, the three real and one virtual pilot are now "launched" on their mission. One of the pilots needs practice with refueling procedures. The other two don't. *DARWARS* provides the refueling exercise to the one, but bypasses this for the other two and, instead, uses that time to give them a navigation exercise. The scenarios of the three join shortly, none of the pilots even knowing that they were separated in the virtual world. The system then compresses time to eliminate the many-hour flight to the target area. Soon the attack aircraft pilots are talking to the soldier "on the ground."

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The *DARWARS* system continues searching through its personnel databases and notes that the soldier has not practiced point-of-wound emergency medical care for over six months. Mastery of the five principles and 15 procedures of personal emergency medicine decays with time and must be periodically driven into a soldier's midbrain. *DARWARS* adjusts the scenario so that enemy resistance increases. In imminent danger, the soldier calls for close air support. One pilot decides to risk a strafing run, flying below his doctrinal hard floor. He halts the enemy, but in the process is shot down by a man-portable anti-aircraft missile, thus providing an injury for the soldier to treat. (If the pilots don't come down, then *DARWARS* might have an enemy shoot the avatar of the commander to provide a wound for the real soldier's training.)

Shortly after taking care of the downed pilot, the soldier is called away for a real-world meeting, but the system creates a temporary avatar for him so that the remaining pilots can complete their mission. They "fly home." After his meeting, the soldier returns to practicing his language skills with the virtual indigenous commander.

In time, each of the participants collaborates with the local and distributed computer system to create after action reviews. All the parties, humans, avatars and various levels of computers discuss, by voice or electronic messaging, what happened. They agree upon lessons learned, and disputes are sent off to be adjudicated by others. "Lucky" is sorted from "good." Skill is separated from artifacts of *DARWARS* and the lessons are used to improve future training, doctrine, weapon systems, and the *DARWARS* architecture itself.

On the carrier, the pilot who got shot down broods in his stateroom late into the night. Then he sits down in front of his laptop computer and, using simple tools made available for the purpose, he creates a new pilot training module that puts the 2013 equivalent of Obewan Kenobi on the next pilot's shoulder so that s/he will be coached not to make the same mistake.

The Vision

Imagine this process proceeding continuously, dishing out military training tailored to individuals, units and staffs as a universal, ubiquitous, persistent, on-demand, multi-participant training system. It would train not only pilots and soldiers, but naval, logistics, intelligence and support forces; active, Guard and reserve. It might eventually be adaptable to help train a local fire or police department in emergency response procedures. Whoever you are, whatever your current skill level, whether as an individual or in a team you are inserted into the training scenario in a way that meets your needs to boost your *cognitive* skills. If there isn't a scenario ready, you or the system can build one to suit.

DARWARS would not replace field training. Nor would it teach what it feels like to patrol on foot through thick grass or take high g-forces in an aircraft, but it would give you repeated practice of what to look for and what to think about when doing such things. It would not reproduce the shock of a weapon going off 100 yards away from a soldier, but it would prepare our warriors' minds with so many practiced instances of tactical thinking that even in shock they would instinctively know what to do.

What this vision of training *would* replace is the tiresome schoolhouse lecture course, the content of which we forget after three months. It *would* replace the shipboard training that consists of flipping a coin in the sonar room to see who gets to read the technical manual aloud to the rest of the sonarmen for the next 45 minutes. It *would* allow our forces to practice routinely things that can't be practiced today, e.g. for safety reasons, in a live environment and to consider threats that we simply don't have time or resources to include in large-scale military exercises. It *would* make our forces *want* to train.

Why We Need This

The American military is dedicated to transforming itself. Each part of our forces have their own name for the transformation, ranging from Network-Centric Warfare to

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Joint Vision 2020, but all of these visions have an unintended, and mostly unexplored, human consequence: everyone, down to the most junior levels, is going to have to think. Everyone will have to perform hard cognitive tasks if they are to succeed in the new warfare environment. There is little in our real-world background that will prepare our future warriors for this environment.

Imagine a 2020 warrior in the middle of a muddy field late at night. A computer icon has replaced the direct human contact with his buddies, which we have known since at least the time of Alexander the Great, is what motivates him to fight under stress. He has 90 pounds of electronics on his back. He is tired. He is wet, and, while the bits and bytes are flying faster than the bullets, he must perform some serious tactical thinking to achieve his mission, and to stay alive. The only help system designers will provide him in this net-centric high-tech task will be the military-specification equivalent of commercial software pop-up help systems.

This won't work. Nor can schoolhouse training prepare our fighters for this future; classroom lessons are static and they decay rapidly out of the heads of the students. Moreover, technology and tactics will change too rapidly for the traditional on-the-job training paradigm of "apprentice to journeyman to master" work well. Current distance learning initiatives will not suffice either. Although a necessary step toward solving military training, the distance learning now focuses on creating a system for delivering data to computers. Little, however, is being done to bridge the last meter to the human: to go from the bytes within a computer to knowledge and understanding inside the head of our transformed warriors. We will need a new kind of training paradigm and new kinds of training devices if we are to jump that last meter. We will not meet the promise of a transformed military if we don't match the revolution in military affairs with a revolution in training.

It will be harder than that, even.

Our future warriors, every single one who enters the military, will need training not only in the cognitive skills of the new warfare but how to fight in the older ways, too. Without that, they will fail when the new technology degrades or is unavailable. We can't drop current military training tasks in order to gain time to teach our warriors to perform the new cognitive tasks. Our people will still have to conduct physical training, live-fire training, and participate in field exercises that use the real hardware. Real ships must still go to sea, real missiles be fired and real torpedoes launched, because the real world will always have surprises for us that the virtual world won't duplicate.

Our military is struggling to find time, money, and training content just to prepare our warriors and our support system to fight with the weapons that we have now. The current cottage industry for military training can not match the pace of weapons technology change with a training development process that currently requires 18 months to create a two week course. Nor do we have enough experts in the military for them to serve as both warriors and trainers. Even if we had, their expertise would decay between operations, both from the natural skill decay and the rapidity of technology change.

Moreover, "Systems continue to be created and then fielded with little consideration for the costs that must be incurred during the life cycle to train the weapon's users. … Systems are fielded: without training aids, devices, simulators, and simulations needed for sustainment training [and] to training installations (1) late, (2) in the wrong quantity, or (3) in a different configuration than that fielded to units. [Thus] the sins of the acquisition process shall be visited upon training systems unto the last generation as training pays the bills for design and production failures.[*]"

[*] Braddock, J., Chatham, R.; *Training for Future Conflicts;* Defense Science Board Report; 2003; p.44. See also their DSB report *Training Superiority & Training Surprise;* 2001; p.10,11 for some egregious examples.

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On top of that, every one of us has been educated to within an inch of our lives and much of what we remember about the process is not pleasant. The very words "training" and "course" brings up boring and negative connotations. Hear those words and you immediately think of tiresome lectures and reading abstruse technical manuals.

What *DARWARS* Might Do

The *DARWARS* vision of continuously available cognitive training for everyone would address many of these military training issues. The gaming aspect could compel our competitive service members to practice and train. Training applications would be developed by the users themselves, who would then feel that they had a stake in the system. The cost of developing training applications and the time to develop them would be reduced. As the system became more available, the hardware developers might insert their emerging designs into the continuous virtual war and find out how real warriors would use their systems, and how they might fail in use. Hardware developers might thereby be encouraged to make engineering trades to help real people succeed with the new weapons. We could use *DARWARS* to learn how we might fight in unexpected situations in future come-as-you-are wars. We could insert show-stopping situations, like electronic warfare and naval mine warfare into the *DARWARS* conflict *du jour*, things that we can not now afford to put in large, expensive military exercises. All our forces could learn about the interoperability of their systems with those of the other services. They could routinely train at the lowest levels for joint missions instead of training in the current mostly service-centric way. *DARWARS* would therefore help accomplish the step-function improvements in military capabilities that are the goal of our current DoD-wide transformation initiatives.

Why This Might Be Doable

If even a fraction of the above could be enabled by a continuous virtual (DARPA) war, then the obvious next step is to explore whether it might really be possible to implement that vision, whether there is reason to believe that it could work. There are vast technical and anthropological impediments to changing the current military training process. Still, there are hints that the *DARWARS* vision might be achievable.

Creating Training Superiority for Units

In 1968 the Navy created a training process that, in one year, increased their air-to-air exchange ratio over Viet Nam from 1:1 up to 12.5:1. The Air Force and the Army instituted the same kind of training over the next decade. The essence of the technique is the creation of an artificial war in which even large units can fight against a better than real enemy, the "Red Force'. This independent opponent is made up of some of our own best warriors who are assigned on a permanent basis to fight to the best of their abilities against the units being trained (the Blue Forces) but they must use enemy tactics and equipment. The Red Force usually wins, but, in losing, the Blue Forces learn lessons that they can't now get anywhere else except in combat.

There are two more essential elements in this process of "engagement simulation." First, the battlefield they fight in is a vast Combat Training Center (CTC) that is well instrumented to record the mock battles; there is no question of what happened in each engagement. No longer does the first person to the blackboard win. Second, there are no-holds-barred after action reviews where *everyone* in the unit is encouraged to explore and explain what went wrong and, less often in practice, what went right. If the Blue Forces don't see what went wrong, the Red Forces will tell them. (By the way, the ability to profit from this process appears to be uniquely American; almost no other military culture has been able to do so.)

The next day Blue fights against Red again, reviews how they failed, and engages again, and again. Two weeks of this training can make an already conventionally well-trained unit 5 to 35 times more likely to beat the Red Force (larger units tend toward the

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lower number, smaller units toward the higher value). Our units come out of this training the most proficient warfighting units in the world. Our 100-hour land-warfare victory in Desert Storm is a testament to this kind of training as is the 2003 combat success in Iraq.

Unfortunately, if there isn't a war imminent, a month after a unit comes out of CTC training it can become one of our least ready units. "The personnel system plays musical chairs with unit manning afterwards;[*]" sending the commander and others off to new jobs, thus breaking the interpersonal relationships that were so painfully developed in the process of engagement simulation. Moreover, the CTC process is used only by some of our forces some of the time. *DARWARS* might bottle this experience and export it electronically to individuals and units so the 'bathtub curve' of unit proficiency, which peaks every few years and then drops again rapidly, can be smoothed out and maintained continuously at a high level. The key elements of what works are: build a war against an independent, better-than-real enemy; exercise our forces in this environment; measure what happens; review the successes and failures at all levels; and do it again and again.

Creating Training Superiority for Individuals

The process here is not so well documented, but we have a few hints of what trains individuals. First are human tutors. A good tutor can improve a student's performance by two standard deviations, two letter grades, over classroom training.[†] They do this in part because they can drive the student to many more active interactions with the subject matter. Computers have obvious potential here. The other reason that tutors succeed is that they build a model of the student in their heads (Here, as opposed to the unit training case, there is less scientific but much anecdotal data to support this hypothesis). The human tutor watches the student to see whether s/he is attentive, asleep, or looking the window out at the squirrels. The tutor knows what the student did yesterday, and how s/he approaches learning, and then the tutor adapts the lessons to match. To emulate this, we will need computers that see their users as something more than a source of bytes input from a keyboard.

We also know that computer-mediated games teach lasting lessons. How to kill a particular monster or get the Babel Fish in your ear are not useful military or life skills, but, done right we could harness the emotional content and compelling nature of games to teach more valuable lessons. We don't yet understand on a quantitative level what makes games compelling to use, less so what makes their lessons last. There is no taxonomy of color, sound, motion, orienting responses, levels, scoring, plot, pacing that tells us what works and when, but some combination of them clearly does work.[‡] We need research to find out why.

Similarly, lessons emerging out of the growing massive multiplayer online game phenomena suggest that such games can create a strong sense of ownership in the process, develop teams, improve team cohesion, and encourage willing and innovative contributions to the whole system from the users themselves. We need to harness these forces for learning.

Paradoxically, human-human interactions are another class of learning tools that new electronic training systems will need to employ. Most people learn from peer contact. For today's students many of those interactions are computer mediated: chat rooms, bulletin boards, instant messaging and the like. We need to escape from the notion that a computer training device must be independent of the official intelligences of this world: real people. When the student and our new kind of trainer get stuck (and they will), the system

[*] Braddock and Chatham; *Training for Future Conflicts*; Op. cit.; p 35

[†] Bloom, B.S., The 2-Sigma Problem; *Educational Researcher*, 13(6); 4-16; 1984

[‡] Green, S.C., Bavelier, D.; Action Video Game Modifies Visual Selective Attention; *Nature*; Vol 423; 534-537 29May 2003

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(which includes the user) should recognize this. The artificial intelligence in the computer might say, "I don't understand you, and you don't understand me. Should we wake up somebody in the Training and Doctrine Command and have him put us back in line, or do you want to post a note on a bulletin board?" While the external official intelligence is being appealed to, the trainer and the student go off in another direction, leaving that frustration behind until it can be resolved.

Finally, we know that after action reviews, which encourage the user to reflect upon the learning process, contribute strongly to the success of unit training. This works for individuals, too.

How We Might Get from Here to There

The Defense Advanced Research Projects Agency is starting a program that we hope will lead to the training future hinted at by the story at the beginning of this essay. We will try to create individual and small-unit training devices that teach cognition: not so much how to don an oxygen breathing apparatus, but what to think about when you arrive at the shipboard fire wearing one; not so much what it feels like to treat a sucking chest wound, but to instill a mid-brain certainty of what you have to do and what not to do when faced with the real situation – because you have seen it in the virtual world over and over again in multiple variations.

These training devices will work on that last meter between data in a computer and understanding between the ears of an official intelligence, a human being. "Last-meter" trainers will dynamically measure and assess a user's/student's state and react accordingly. They might shift to a game mode when the student is getting bored. The user and the artificial intelligence will reach back to an outside official intelligence when they get stuck. Last meter trainers will know the student and tailor the lessons to their history and training needs. Finally, instead of the user/student thinking "Oh no, not more training," s/he will willingly use the system and feel a strong sense of ownership of it. If done right each last-meter training device will evolve to become a job performance aid that delivers warfare proficiency when and where it is needed.

The DARPA program will not stop there. We hope to link these new last-meter training devices, existing training systems, and real warfare systems, all together in an architecture where everybody, individuals and units, can train any time anywhere with whatever low-cost computing device comes to hand (or to eye, or to ear). The system of systems will recognize the users, determine what they need, tailor a training scenario for them within the current DARPA Virtual Training War, and then, in collaboration with the user, assess and score the *learning* gained from the process.

Our current training superiority is based upon creating a training war and practicing within it. There is neither time nor resource to do this continuously in the field, but it may now be possible to practice the cognitive aspects of warfare continuously, on demand, at all levels in a virtual world. In doing so, *DARWARS* may move us from an episodically-trained standing military in peace to a peaceful military continuously at war in the virtual world. Our transformed military will thus be superbly ready to perform whatever mission is required of it because every member and every unit will have practiced and rung out many changes on that mission theme in the training world.

Mark Twain wrote that being a Mississippi riverboat pilot stood him in good stead as an author, because every personality type he subsequently encountered he already knew, "I met him on the river." In the same way, this new training vision might make our forces able to meet the unexpected challenges of future conflicts; we will have fought them before in *DARWARS*.

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