Training the Professional Soldier: Bridging Inexperience and Sophisticated Warfighting Technologies

A Monograph

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The US Army of 2021 faces challenges similar to those seen during the post-Korean War and post-Vietnam War periods. These two periods of history highlight material and personnel revolutions that required a change in training. During the post-Korean War period, the US Army struggled to adequately train its human capital on the use of sophisticated weapons and then retain them in sufficient numbers to build readiness. During the post-Vietnam War period, the US Army transitioned to the All-Volunteer Force. The All-Volunteer Force eventually leveraged further technology advancements to adopt a training and professionalization culture analogous to the training and professionalism of licensed practical nurses, licensed industrial technicians, and skilled tradesmen. This achievement is also the US Army's Achilles heel, since units cannot train and certify such specialists overnight. If large-scale combat operations result from the current competitive policies of Russia, China, Iran, or North Korea, the US Army will need to have already in place a supportive cognitive environment for training inexperienced replacements on sophisticated weapon systems maintenance. Augmented reality is an information-age training methodology and aid that combines point-of-need training, improved training efficiency, and a resilient training strategy. Its adoption by the army will bridge the inexperience gap of newly-inducted or newly-enlisted soldiers, allowing them to immediately engage in sophisticated weapon systems maintenance.

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Abstract

Training the Professional Soldier: Bridging Inexperience and Sophisticated Warfighting Technologies, by MAJ Michael L. Hefti, 50 pages.

The US Army of 2021 faces challenges similar to those seen during the post-Korean War and post-Vietnam War periods. These two periods of history highlight material and personnel revolutions that required a change in training. During the post-Korean War period, the US Army struggled to adequately train its human capital on the use of sophisticated weapons and then retain them in sufficient numbers to build readiness. During the post-Vietnam War period, the US Army transitioned to the All-Volunteer Force. The All-Volunteer Force eventually leveraged further technology advancements to adopt a training and professionalization culture analogous to the training and professionalism of licensed practical nurses, licensed industrial technicians, and skilled tradesmen. This achievement is also the US Army's Achilles heel, since units cannot train and certify such specialists overnight. If large-scale combat operations result from the current competitive policies of Russia, China, Iran, or North Korea, the US Army will need to have already in place a supportive cognitive environment for training inexperienced replacements on sophisticated weapon systems maintenance. Augmented reality is an information-age training methodology and aid that combines point-of-need training, improved training efficiency, and a resilient training strategy. Its adoption by the army will bridge the inexperience gap of newly-inducted or newly-enlisted soldiers, allowing them to immediately engage in sophisticated weapon systems maintenance.

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Abbreviations

AUSA	Association of the United States Army
AVF	All-Volunteer Force
CASCOM	US Army Combined Arms Support Command
CATS	Combined Arms Training Strategy
CATT	Combined Arms Tactical Trainers
FAMSIM	Family of Simulators
FLMNET	Field-Level Maintenance New Equipment Training
HUD	Heads-Up Display
IRR	Individual Ready Reserve
IVAS	Integrated Visual Augmentation System
LSCO	Large-Scale Combat Operations
MDO	Multi-Domain Operations
MILES	Multiple Integrated Laser Engagement System
MOS	Military Occupation Specialty
NCO	Non-Commissioned Officer
NTC	National Training Center
OPNET	Operator New Equipment Training
SCOPES	Squad Combat Operations Exercise Simulation
SIMNET	Simulation Network
TRADOC	US Army Training and Doctrine Command

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Introduction

> No matter what is done, no matter what method is used, one should always remember that our wartime recruits are sent into squadrons as into battalion with hasty, incomplete training, and if you give them lances most of them will just have sticks in their hands, whereas a straight sword at the end of a strong arm is both simple and terrible.
>
> —Charles Jean Jacques Joseph Ardant du Picq, *Battle Studies*

In *The US Army in Multi-Domain Operations 2028*, General Mark A. Milley argues for a shift in training paradigms and preparation for new technologies' impacts. Milley asserts that artificial intelligence, nanotechnology, and robotics can revolutionize battlefields unlike anything since integrating tanks and aviation into the era of combined arms warfare.[1] Based on historical trends, technological advancement requires considerable growth in training to maintain and support it. This training growth highlights the relationship between technology and the volume of information produced.

As the US Army emphasizes Multi-Domain Operations (MDO), the US Army's Training and Doctrine Command (TRADOC) must adjust training methods and aids to account for the ever-increasing volumes of information required to maintain increasingly sophisticated weapon systems. Current US Army weapon systems already highlight this need. For example, the most recent operator-level technical manual for the M1A2 Abrams Main Battle Tank consists of four volumes numbering 4,674 pages.[2] Carl von Clausewitz's timeless treatise *On War* comprises just one-seventh that number.[3] However, despite the technical manual's length, leaders expect the newest private, young non-commissioned officers, and new lieutenants who work on tanks to know those 4,674 pages and use the information in them properly. If the past is any guide, future

[1] US Department of the Army, TRADOC Pamphlet 525-3-1, *The US Army in Multi-Domain Operations 2028* (Washington, DC: Government Publishing Office, 2018), Foreword.

[2] Technical Manual information accessed 14 September 2020 through Electronic Technical Manuals with an active account at https://enterprise.armyerp.army.mil/liwportal/.

[3] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton: Princeton University Press, 1976).

weapon systems will only become more sophisticated and challenging to maintain, with less time to train those responsible for maintenance.

As the US Army returns to a focus on large-scale combat operations (LSCO), the potential for high attrition increases when compared to low-intensity conflict. A forty-four day high-intensity regional conflict regarding the status of the enclave of Nagorno-Karabakh in 2020 demonstrated this potential, resulting in at least 2,783 Azerbaijani and 2,317 Armenian soldiers killed.[4] During prolonged large-scale combat operations, personnel losses will require the rapid assimilation of new soldiers into the service in response to casualties, not dissimilar to the 2014 Russo-Ukraine conflict. From 2014 to 2015, Ukraine suffered at least 10,710 military casualties and mobilized over 100,000 new personnel.[5] Newly assimilated soldiers will likely experience a compressed training cycle and participate in collective training or operations before fully grasping how to properly maintain their equipment. If the rapidly reconstituted force cannot correctly maintain new warfighting technologies, commanders cannot expect the formation to fight, survive, and win on the MDO battlefield.

The US Army has addressed similar challenges in the past by adjusting its training methods to account for new warfighting technologies. Historically, such adjustments create the most significant impact when made during peacetime—in an "interwar" period. Two such examples with direct application to today include the post-Korean War period (1953-1962) and the post-Vietnam War period (1975-1990). Future thinking senior leaders improved training during these two distinct periods and revealed a direct correlation between technology and training. As technology increased in complexity, hours devoted to training also increased.

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[4] Tom Balmforth, "Azerbaijan Says 2,783 of Its Soldiers Killed In Karabakh Conflict," *Reuters*, 03 December 2020, accessed 15 January 2021, https://www.reuters.com/article/us-armenia-azerbaijan-troops/azerbaijan-says-2783-of-its-soldiers-killed-in-karabakh-conflict-idUSKBN28D1DU.

[5] Valeriy Akimenko, "Ukraine's Toughest Fight: The Challenge of Military Reform," *Carnegie Endowment for International Peace*, 22 February 2018, accessed 15 January 2021, https://carnegieendowment.org/2018/02/22/ukraine-s-toughest-fight-challenge-of-military-reform-pub-75609.

The US Army's adaptation to new warfighting technologies during the post-Korean War and post-Vietnam War periods inform current initiatives to improve soldier training efficiency, given the ever-increasing volumes of information required to maintain increasingly sophisticated weapon systems. The research shows that the US Army incorporated technology to improve the quality of individual training of new sophisticated weapon systems. Based on that precedent, and while accounting for current technological advances, augmented reality has become the best technology for improved training during the last decade.[6] While numerous training methodologies and aids exist at every echelon, augmented reality uniquely combines point-of-need training, improved training efficiency, and a resilient training strategy, thereby bridging the inexperience gap for sophisticated weapon system maintenance.

In addition to the emergence of new technologies, during the post-Korean War period, the US Army struggled to adequately train its human capital on the use of sophisticated weapons and then retain them in sufficient numbers to sustain readiness. In 1956, the US Army set reenlistment goals at twenty-five percent for radar technicians and thirty-three percent for electronic technicians; however, the actual retention rates were one percent and eight percent, respectively.[7] The US Army also drastically changed the education standards for accessions during the 1950s. By 1960, army leaders expected a bachelor's degree for officers and a high-school diploma for non-commissioned officers.[8] During the post-Vietnam War period, the US Army transitioned to the All-Volunteer Force (AVF). With a simultaneous policy change that no longer allowed soldiers to spend a twenty-year career as a private soldier, this transition

[6] Mustafa Fidan and Meric Tuncel, "Augmented Reality in Education Researches (2012-2017): A Content Analysis," *Cypriot Journal of Educational Sciences* 13, no. 4 (2017): 585, accessed 28 August 2020, http://search.ebscohost.com.lumen.cgsccarl.com/login.aspx?direct=true&db=eric&AN=EJ1202226&site=ehost-live&scope=site.

[7] Brian M. Linn, *Elvis's Army: Cold War GIs and the Atomic Battlefield* (Cambridge, MA: Harvard University Press, 2016), 125.

[8] Ibid., 270.

contributed to a readiness gap that prevented the army from being able to fight outnumbered and win during a conventional fight. The US Army used lessons from the 1973 Arab-Israeli War to restructure its organization and revolutionize its training at all echelons.

The individual soldier's heightened intellectual aptitude became the hallmark that the AVF used to leverage further advancement in technology and adopt a training and professionalization culture analogous to licensed practical nurses, licensed industrial technicians, and other skilled tradesmen. This achievement also became the US Army's Achilles heel, since organizations cannot train and certify such specialists overnight. If large-scale combat operations result from the current competitive policies of Russia, China, Iran, or North Korea, the US Army will need to have already in place a supportive cognitive environment for training replacements on sophisticated equipment. If TRADOC and the US Army Combined Arms Support Command (CASCOM) do not develop a system for rapid transfer of cognitive information, the newly-accessed soldiers will embody Ardant du Picq's warning about the value of untrained personnel: "…if you give them lances most of them will just have sticks in their hands..."[9]

The post-Korean War and post-Vietnam War periods provide insight into understanding interwar growth and modernization. Army tactical units commonly focus on the basics of shooting, moving, and communicating. However, the weapon will not shoot, the vehicle will not move, and the radio will not communicate without soldiers trained to maintain them. In 1959, XVIII Airborne Corps commander Lieutenant General Robert F. Sink observed that push-button trucks were easier for "idiots" to operate but required geniuses to maintain.[10] By 1986, retired TRADOC commander General William E. DePuy concluded that the complexity of maintenance requirements for technologically advanced equipment exceeded the quantity and quality of

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[9] Charles Jean Jacques Joseph Ardant du Picq, *Battle Studies*, ed. and trans. Roger J. Spiller (Lawrence, KS: University Press of Kansas, 2017), 112.

[10] Lieutenant General Robert F. Sink, "An Analysis of STRAC Tactical and Strategic Mobility" (lecture given at the Army War College, 24 May 1959).

maintenance technicians in the US Army.[11] The post-Korean War and post-Vietnam War periods highlight the growing challenges associated with maintaining new sophisticated weapon systems.

History informs the military practitioner of relationships between modernization and training. One of the most important relationships is the difference in effectiveness between a trained soldier and an untrained one. Experience to date demonstrates the likelihood that augmented reality can bridge inexperience and sophisticated weapons system maintenance. Augmented reality does this by combining point-of-need training, improving training efficiency, and providing a resilient training strategy. As a result, augmented reality enhances the application of the synthetic training environment. In the future, augmented reality will speed the cognitive transfer rate of technical information to new soldiers during rapid mobilization periods.

As part of the existing synthetic training environment, TRADOC's Program Executive Office Soldier began incorporating augmented reality as part of the Integrated Visual Augmentation System, known as IVAS, and plans to field it in 2021.[12] The IVAS uses augmented reality to show weapon optics, soldier location, friendly and enemy location, night vision capability, and possibly facial recognition and text translation.[13] However, the new IVAS focuses only on battlefield capabilities; it misses the platform's critical application to a disbursed maintenance environment and cross-training requirements for low-density and high-demand technical skill sets.

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[11] Namoi Verdugo and Nehama E. Babin, *The Impact of Advanced Technology on the US Military* (Alexandria, VA: US Army Research Institute, 1990), 12, accessed 14 September 2020, https://apps.dtic.mil/dtic/tr/fulltext/u2/a220181.pdf.

[12] Todd South, "Soldiers, Marines Finish First Test of Ruggedized 'Do-It-All' Augmented Reality Goggle," *Army Times*, 03 November 2020, accessed 15 January 2021, https://www.armytimes.com/news/your-army/2020/11/03/soldiers-marines-finish-first-test-of-ruggedized-do-it-all-augmented-reality-goggle/?fbclid=IwAR3B5Xt6k_xyWInT7rJpNTur9Ymj1l7vZTobr7ECDtM85hsjYvjsO0P0XM8.

[13] Dylan Malyasov, "US Army Plans to Field Augmented Reality Goggles by 2021," *Defence Blog*, 02 November 2020, accessed 15 January 2021, https://defence-blog.com/news/army/u-s-army-plans-to-field-augmented-reality-goggles-by-2021.html#.

Three facts compel CASCOM and TRADOC to accelerate the application and improvement of maintenance training through augmented reality. Augmented reality improves point-of-need training by generating remembered hands-on experiences for soldiers, a personalized curriculum based on skill level and aptitude, and an accelerated knowledge transfer rate compared to legacy training methods. Second, augmented reality improves training efficiency by increasing soldiers' motivation to learn, unit training programs' effectiveness, and the acquisition of the technical skills required to repair sophisticated weapon systems. Finally, augmented reality creates a resilient training strategy by mitigating skill shortages, minimizing the expansion of existing infrastructure, and increasing full system design capability.

The US Army requires its professionals to possess specialized knowledge.[14] In a future war, the US Army might be able to draft individuals as it did from 1940 to 1973, but it will not draft today's professionals' experience.[15] As the US Army continues developing its synthetic training environment, CASCOM and TRADOC must consider augmented reality as a tool to bridge inexperience and sophisticated weapon system maintenance requirements through point-of-need training, improved training efficiencies, and resilient training strategies.

A Historical Review: Emerging Technology and Training Relationships

This literature review studies the US Army's intellectual revolution in training. It focuses on the relationships between emerging technologies and training. TRADOC owes its existence to the army's pursuit of technology that augments and improves training efficiency. A review of US Army history identified the post-Korean War period (1953-1962) as a transitional phase characterized by improved training techniques and new, more sophisticated training

[14] Benjamin Jensen, *Forging the Sword: Doctrinal Change in the US Army* (Stanford, CA: Stanford University Press, 2016), 15.

[15] James Kitfield, *Prodigal Soldiers* (Washington, DC: Brassey's, 1997), 89.

technologies.[16] While an infinite number of links in the chain of events exists, the continuities that extend from that time to today illuminate a correlation between sophisticated weapons technology and training technology.[17] These continuities originate deep in human history, strongly arguing for their applicability to the US Army's integration of augmented reality as a training methodology and aid.

Building on the foundations of Thomas S. Kuhn's work, Michael Bonura's intellectual revolution theory posits that a paradigm shift occurs when organizations culturally accept new ideas, experience a military crisis on the battlefield, and find strong military leaders who champion the new conceptualization.[18] Using Bonura's framework, we can identify a cultural acceptance of technology in training that accelerated during the post-Korean War period and then declined during the army's long engagement in Vietnam, before the US Army vicariously experienced a military crisis in the 1973 Arab-Israeli War. This military crisis led multiple army leaders to champion improved training technologies during the post-Vietnam War period. New training technologies bridged the gap between recruits' inexperience and sophisticated weapon systems.

Although the American way of war has often favored machinery and technology to save manpower, the US Army's institutional experience of the Korean War led to an accelerated adoption of new technologies.[19] At the start of the Korean War, US Army equipment and

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[16] John Lewis Gaddis, *The Landscape of History: How Historians Map the Past* (New York: Oxford University Press, 2002), 98-99.

[17] Ibid., 30-31, 175, 106.

[18] Michael A. Bonura, *Under the Shadow of Napoleon: French Influence on the American Way of Warfare from the War of 1812 to the Outbreak of WWII* (New York: New York University Press, 2012), 260-262; Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, IL: University of Chicago Press, 1970), 77-91.

[19] Andrew J. Bacevich, *The Pentomic Era: The US Army between Korea and Vietnam* (Washington, DC: Government Publishing Office, 1986), 55.

doctrine remained unchanged from those used during World War II.[20] After the Korean War, successive US Army chiefs of staff General Matthew B. Ridgway and General Maxwell D. Taylor realized the army no longer possessed the luxury of extended time to mobilize before engaging in large-scale combat operations (LSCO), and looked to more sophisticated weapon systems and technology as a way to increase lethality from the start. With new technology came more complexity. Truck drivers in World War II could perform most of the necessary maintenance on their vehicles themselves, but increasingly complex vehicles would require a skilled mechanic only a decade later.[21] New technologies like the M28/29 Nuclear Recoilless Gun and M60 Patton Main Battle Tank directly challenged existing army maintenance training practices.

Post-Korean War Period (1953-1962) – Rapid Technological Impacts

The Korean War changed the concept of readiness. The US Army no longer had the luxury of extended mobilization and train-up periods like those experienced at the start of American participation in World War I and World War II. The 1955, US Army Vice Chief of Staff General Williston B. Palmer bluntly stated that the future would no longer allow for long train-up.[22] Senior leaders attempted to mitigate reduced training time by emphasizing technological overmatch and mobility as the answer to winning future atomic age wars.

In order to stay relevant under the "New Look" US National Security Policy and heavy favoritism of the US Air Force and US Navy, the US Army emphasized battlefield atomic weapons and technology as a way to increase mobility and lethality.[23] Two years earlier, the 1953 chief of staff, General Ridgway had already articulated a need to increase mobility and firepower

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[20] Robert A. Doughty, *The Evolution of US Army Tactical Doctrine, 1946-76*, Leavenworth Paper, No. 1 (Fort Leavenworth, KS: Combat Studies Institute, US Army Command and General Staff College, 1979), 4.

[21] Linn, *Elvis's Army*, 121.

[22] Bacevich, *The Pentomic Era*, 59-60.

[23] Doughty, *US Army Tactical Doctrine*, 14.

since potential adversaries would outnumber the US Army in the future.[24] This emphasis at the senior leader level produced the most complex equipment the military had seen in the past decade.[25] A paradox emerged, as technology made a soldier's job of operating the equipment easier but required more skill and different soldiers to maintain it.

The post-Korean War period saw the US Army experiment with new technologies in computers, electronics, and missiles, requiring skilled technicians with months or years of schooling to operate and maintain. Just as the American industrial-age workforce changed, the US Army needed to change to a workforce of skilled technicians instead of semi-skilled laborers.[26] In *Elvis's Army*, Brian Linn summed it up best when he asserted, the "geek" programing a 1950s missile guidance system was more lethal than a hundred Audie Murphys.[27] The character of the soldier's core task of fighting was quickly changing and required a specialization only more training could provide.

The post-Korean War period continued to anchor the US Army in technology as a way of war. The Vietnam War later taught leaders that technology alone did not win wars. That war highlighted technology's limits, particularly when unsupported by doctrine or a logistical tail of maintenance and a skilled workforce. The post-Vietnam War period revealed that technology did not simplify warfare; rather, it underlined the fact that without a skilled workforce to maintain it, new technologies seldom performed to their full potential.[28] Thus, the need for specialized and skilled soldiers would only grow, along with the use of technology as a warfighting enabler.

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[24] Doughty, *US Army Tactical Doctrine*, 16.

[25] Bacevich, *The Pentomic Era*, 53, 120-121; Linn, *Elvis's Army*, 99.

[26] Linn, *Elvis's Army*, 134.

[27] Ibid., 99.

[28] Ibid., 134.

1973 Arab-Israeli War – The Military Crisis

As the American military completed its exit from the Vietnam War, the US Army vicariously experienced a military crisis in the 1973 Arab-Israeli War, contributing to the intellectual revolution. Two relatively sophisticated and technically advanced societies entered a military conflict with modern weapons; together they destroyed the equivalent of three years' worth of tank production in just three weeks.[29] The level of violence in such a short period highlighted the need to win the first battles, especially with the US Army positioned at the Fulda Gap on the inter-German border, where Warsaw Pact tanks outnumbered US tanks by more than double.[30]

During the same year as the Arab-Israeli War, the US Army began an internal reorganization known as Operation Steadfast, resulting in the creation of TRADOC, built to reduce the Continental Army Command bureaucracy and spur innovation.[31] As a priority, US Army Chief of Staff General Creighton W. Abrams ordered the new commander of TRADOC, General William E. DePuy, to examine the crisis, focusing on tactics, techniques, organization, training, and equipment performance.[32] Army leadership took away three significant lessons. First, modern weapons were far more lethal than previously acknowledged.[33] Second, a combined arms team's employment with the proper support and sustainment could mitigate modern weapons' lethality in the defense and enhance their effects in the offense.[34] Finally, individual training and the team's collective training would determine success or failure, especially during the first fight.[35]

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[29] Kitfield, *Prodigal Soldiers*, 152-153.

[30] Ibid.

[31] Jensen, *Forging the Sword*, 31-32.

[32] Ibid., 33.

[33] Ibid., 52.

[34] Ibid.

[35] Ibid.

The post-Vietnam War period became a fifteen-year study and implementation of lessons learned from this military crisis. The US Army, as an institution, refined TRADOC's role, released new doctrine, and then enforced new doctrine with Skill Qualification Tests and the Army Training and Evaluation Program. The institution also established the National Training Center to validate training technologies such as the Multiple Integrated Laser Engagement System (MILES). Senior leaders influenced these ideas, most of which TRADOC championed and implemented as an organization. These new ideas became part of a new paradigm in training. One of the emerging ideas was the application of training technologies to bridge soldier inexperience with sophisticated weapon systems.

Post-Vietnam War Period (1975-1990) – The Championing of New Ideas

The post-Vietnam War period was one of the most turbulent interwar periods in US history and arguably of greater significance than any other US interwar period. An All-Volunteer Force (AVF), new doctrine, new large-scale maneuver training centers, the "Big Five" hardware procurements, and computerized simulations highlight some of the significant changes.[36] Simulations and application of technology to improve training at every echelon show how the US Army adapted to new warfighting technologies. The army's experience in Vietnam, and the lessons it took from the Yom Kippur War, led directly to initiatives that matured into what the US Army uses today to minimize the knowledge gap between soldiers and the maintenance requirements of sophisticated warfighting technologies.

The post-Vietnam War period saw technological changes whose cultural impact on the US Army made the technological advances between the Civil War and World War II pale in comparison.[37] Army leaders such as General DePuy and his Deputy Chief of Staff for Training,

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[36] John L. Romjue, Susan Canedy, and Anne W. Chapman, *Prepare the Army for War: A Historical Overview of the Army Training and Doctrine Command, 1973-1993* (Fort Monroa, VA: Office of the Command Historian, US Army Training and Doctrine Command, 1991), 44.

[37] Doughty, "*US Army Tactical Doctrine*," 42; Verdugo and Babin, *Impact of Advanced Technology*, 1.

Major General Paul F. Gorman, knew American technology needed to match adversaries like the Soviet Union.[38] However, technology alone failed without a trained soldier, and technology made training increasingly complex. A clear theme began to emerge. The US Army had to train for victory in LSCO without a long mobilization period so that the AVF could win the first fight.

In an August 1976 presentation, Major General Gorman estimated that the US Army would acquire sixty to seventy percent more weapon systems in the next decade, more than any other comparable period.[39] TRADOC needed a training system that would support such sophistication.[40] According to Gorman, the US Army could no longer "be dependent on mobilization or a long period of fumbling through training."[41] Gorman understood this from his 1970 experience as a brigade commander in the 101st Airborne Division, when he found that most of his soldiers did not know how to zero their weapon correctly.[42] Time remained a constraint that no amount of collective training could fix. TRADOC needed efficiency.

TRADOC faced changes in warfighting technologies so rapidly that they outpaced training doctrine. General DePuy and Major General Gorman recognized this dilemma and the need for more efficient and cost-effective training.[43] One of the first technologies they applied was audio-visual training extension courses, which delivered training to the point-of-need.[44] However, the 1978 Battlefield Development Plan still expressed concerns about properly training

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[38] Kitfield, *Prodigal Soldiers*, 158; Walter E Kretchik, *US Army Doctrine: From the American Revolution to the War on Terror* (Lawrence, KS: University Press of Kansas, 2011), 177.

[39] Major General Paul F. Gorman, "Presentation by MG Gorman, Armed Forces Staff College" (presentation given at Norfolk, VA, 23 August 1976), 23.

[40] Ibid.; General Donn A. Starry, *Press On!: Selected Works of General Donn A. Starry* (Fort Leavenworth, KS: Combat Studies Institute Press, 2009), 705.

[41] Gorman, "Presentation Armed Forces Staff College," 5.

[42] Kitfield, *Prodigal Soldiers*, 159.

[43] Romjue, Canedy, and Chapman, *Prepare the Army*, 21-22.

[44] Ibid., 32.

soldiers as the US Army continued introducing new warfighting technologies.[45] The idea of applying technology to training to facilitate rapid assimilation of new warfighting technologies grew momentum.

The Cold War maintained pressure on developing efficient training strategies. In October of 1979, General Donn A. Starry observed that the increased sophistication of warfighting technologies and a "hostile training environment," due to lack of time, required the US Army to find better ways of training individual soldiers.[46] In April of 1981, Starry expressed his frustrations at a Non-Commissioned Officer (NCO) Training Conference. He could not understand how America had achieved human-crewed space flight, but the US Army still used classrooms, lectures, books, and papers when better technologies existed for training.[47] The rate of technological innovation and a larger volume of information created a dilemma even in peacetime. In Starry's view, the transfer of knowledge to an individual soldier needed to occur faster.

The new weapon systems that the US Army was procuring also created a challenge for the AVF. In 1979, the chief of staff, General Edward C. "Shy" Meyer, expressed concern with current recruits' intelligence level and their ability to exploit the capabilities of emerging technologies like computers, laser range finders, and new imaging devices.[48] Over time, the emerging warfighting technologies forced the US Army to raise the military entrance exam standards, especially in the areas related to maintenance of the new technologies.[49] The technology contributed to a more professional AVF, characterized by specialized knowledge and expertise.

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[45] John L. Romjue, *From Active Defense to AirLand Battle: The Development of Army Doctrine, 1973-1982* (Washington, DC: US Government Printing Office, 1984), 25-26.

[46] Starry, *Press On*, 706.

[47] Ibid., 849.

[48] Kitfield, *Prodigal Soldiers*, 207-208.

[49] Verdugo and Babin, *Impact of Advanced Technology*, 4-5.

As part of professionalizing the force, the US Army continually experimented with applying technology to training strategies. Advancements deemed worthwhile were then adapted over time to increase training efficiency. One of the first technologies used to support training was the Squad Combat Operations Exercise Simulation (SCOPES). Both SCOPES, and a similar system called REALTRAIN for tanks, employed crude simulations that soldiers used in the field to "learn by doing."[50] During the post-Vietnam War period, TRADOC developed other technologies for training, such as MILES, Simulations Network (SIMNET), Combined Arms Tactical Trainers (CATT), and family of simulators (FAMSIM).[51] The specific functions of these technologies are not as important as examining the continuities over time. The most noticeable pattern was TRADOC's continued adoption of increasingly complicated technology to train the soldier more efficiently and effectively.

The US Army continued to pursue and adapt to new warfighting technologies while introducing initiatives that supported training efficiency. From 1984-1986, the US Army introduced and fielded the new Apache helicopter, the Blackhawk helicopter, the Abrams tank, and the Bradley fighting vehicle. These new warfighting technologies favored microchip technology over electromechanical technology, the use of which required constant remedial training and sustained skill retention to maintain.[52] In 1988, TRADOC commander General Maxwell R. Thurman introduced his Vision 91 and Army Training 21 concepts, a partial response to developing leaders whose skills matched their equipment's complexity.[53] He also introduced the distributed training strategy, yet another training program that enabled units to deliver training at the point-of-need.[54] Technological advancements required TRADOC to develop supportive

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[50] Kitfield, *Prodigal Soldiers*, 160; Romjue, Canedy, and Chapman, *Prepare the Army*, 32.

[51] Romjue, Canedy, and Chapman, *Prepare the Army*, 32-47.

[52] Kitfield, *Prodigal Soldiers*, 303-313.

[53] Anne W. Chapman, *The Army's Training Revolution, 1973-1990: An Overview* (Fort Monroe, VA: Officer of the Command Historian, US Army Training and Doctrine Command, 1991), 35-36.

[54] Ibid., 36.

training strategies and deliver them to units in the operating force, not just the generating force units.

The US Army continued to improve training and study the relationship between new warfighting technologies and training efficiencies. Various studies continued to express concern over an anticipated gap between existing training methods and warfighting capabilities the US Army introduced.[55] In 1989, Thurman's successor General John W. Foss oversaw the Combined Arms Training Strategy (CATS) implementation.[56] CATS ensured that units applied the right training aids, simulations, and emerging technologies to the right weapon system, at the right location.[57] Less than two years later, army units validated the application of technology to training during Operation Desert Storm.

The post-Vietnam War period encompassed numerous changes that improved the AVF and army training strategies, continuing a longer tradition of technological adaptation in the army to that time. One of the fundamental changes was using technology to adapt to new warfighting technologies, thereby improving training efficiency. Reflecting the growing consensus regarding an "American way of war," the adoption of sophisticated technology surged in the post-Korean War period, presented a crisis for the US Army in the 1973 Arab-Israeli War, and helped complete a cultural paradigm shift in the post-Vietnam War period. Leaders like General DePuy, Major General Gorman, General Starry, and others championed new uses for highly complex technologies that applied to training, maintenance, and administration as well as the battlefield. In 1990, the US Army, as part of a joint force, used new warfighting technologies, such as the "Big Five," in Operation Desert Storm, a victory that resulted directly from two decades of experimentation.

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[55] Chapman, *The Army's Training Revolution*, 39-41.

[56] Ibid., 39-41.

[57] Ibid.

US Army's Ongoing Challenge with Technology and Information Overload

Operation Desert Storm undoubtedly succeeded, yet unanswered questions remained. A 100-hour ground war did not thoroughly test the logistics and maintenance of new warfighting technologies. Perhaps one of the most critical areas it did not test was American citizens' willingness to submit to a renewed draft or the US Army's ability to train large numbers of recruits on short notice. The US Army still has not validated that its training strategies work fast enough outside of the AVF. While the US Army applied technology to improve operator training, maintaining new warfighting technologies remained expensive and inefficient. A short, intense war that did not require national mobilization could not ascertain whether the US Army employed proper training strategies that allowed for efficient maintenance training in a post-mobilization environment.

The amount of knowledge and information required to maintain new warfighting technologies increases complexity, and the amount of information soldiers need to learn. The post-Korean War period and the post-Vietnam War period both highlighted this challenge, whose complexity will only increase with time. In *The Fifth Discipline*, Peter M. Senge points out that humankind now creates far more information than a single individual can absorb, thereby accelerating change faster than its pace can be tracked.[58] Likewise, IBM claimed the world's population generated ninety percent of the world's data from 2012-2014.[59] Finally, the executive chairman of Google claimed that in two days, people digitally created the same amount of information that existed from the beginning of civilization to 2003.[60] The struggle to reduce complexity and large volumes of information also applies to new warfighting technologies.

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58 Peter M. Senge, *The Fifth Discipline: The Art & Practice of the Learning Organization* (New York: Doubleday, 2006), 69.

59 Elizabeth E. Joh, "Policing by Numbers: Big Data and the Fourth Amendment," *Washington Law Review* 89, no. 1 (2014): 39-40, accessed 14 October 2020, https://digitalcommons.law.uw.edu/wlr/vol89/iss1/3.

60 Ibid.

As new warfighting technologies developed, post-Korean War leaders recognized that a new soldier required more training for maintenance operations than combat operations. In 1958, Colonel Edwin Blake Crabill noted that technology required far more skill to maintain and repair the equipment than it did to operate the equipment.[61] In 1959, Colonel William S. McElhenny observed the US Army could quickly train entry-level soldiers for combat, but training entry-level soldiers to repair and maintain equipment required skill and more training.[62] Although the US Army addressed this by increasing recruiting standards and training, the volume of information continued to grow. The US Army did not address how to reduce the time needed to train support personnel on maintenance requirements.

While leaders in the post-Korean War period focused on the problem of entry-level maintenance training, the post-Vietnam War period leaders emphasized the complexity that resulted from new warfighting technologies. In October of 1980, General Starry told the Association of the United States Army (AUSA) annual meeting that electronic black boxes, like laser rangefinders on tanks, only required a soldier to push a button and learn to read the number.[63] However, the electronic black box's complexity required more time and money for training the maintenance and repair.[64] Twenty-years after the post-Korean War period, the US Army could not provide more efficient ways to train maintenance without spending more time and money on the problem.

Early post-Vietnam War period leaders identified a growing division between the new warfighting technologies' complexity and the skillsets of the soldiers assigned to repair them. General DePuy commented that a combat soldier's job might become more manageable, but electronic maintenance was increasingly difficult and required skills beyond the ability of most of

[61] Linn, *Elvis's Army*, 121.

[62] Ibid., 157.

[63] Starry, *Press On*, 711.

[64] Ibid.

the soldiers the US Army was recruiting.[65] The first TRADOC Deputy Chief of Staff for Training, Major General Gorman, highlighted the growing technical complexity of the XM-1 tank, which required 1,728 technical documents to learn instead of one slim technical manual for the 1940s Sherman tank.[66] In a different speech, Gorman brought all the technical documents required for one tank company and stacked them on stage into a six-foot four-inch-tall tower.[67] Gorman and his staff had identified a potential obstacle to readiness but only answered it with extended training for an AVF.

In the late 1970s, the US Army not only struggled to train entry-level maintenance technicians but also struggled to train entry-level officers in basic technical competence. Even after the training hours doubled for second lieutenants assigned to mechanized infantry battalions, General Starry still found their knowledge lacking.[68] In one poignant example, Starry asked a second lieutenant about an inoperable M113 armored personnel carrier and requested the fault's location. The officer responded that the inoperable M113 had a broken fan tower, which he attempted to identify by indicating the exhaust stack.[69] Even the M113—already two decades old at the time of this incident—required extensive training for its operators to achieve technical competence, let alone the expertise a maintenance technician required.[70] Additionally, expertise could not be achieved when unit commanders only focused an average of just twelve percent of training time on individual training.[71]

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[65] Verdugo and Babin, *Impact of Advanced Technology*, 12.

[66] Major General Paul F. Gorman, "Presentation by MG Gorman, Army War College Class 76" (presentation given at Carlisle Barracks, 4 March 1976), 3.

[67] Gorman, "Presentation Armed Forces Staff College," 19.

[68] Starry, *Press On*, 773.

[69] Ibid.

[70] US Department of the Army, Army Doctrine Publication (ADP) 6-22, *Army Leadership and the Profession* (Washington, DC: Government Printing Office, 2019), paragraph 4-20.

[71] Gorman, "Presentation Armed Forces Staff College," 4.

A 1982 Army Research Institute study determined that M1 Abrams tank crewmen incorrectly performed maintenance tasks specified by the (three-inch thick) technical manual due to the complexity and volume of tasks, many of which required more time to read than to complete.[72] Inspection and preventive maintenance of the 120mm main gun alone consisted of more than one hundred procedural steps and sixteen potential decision points.[73] The research team created a procedural guide to simplify the complexity, but at 111 pages, the guide did not reduce the steps.[74] Despite an effort to mitigate complexity, the reality continued to prove that technological advances across the US Army's catalog of equipment required ever-greater levels of knowledge and skill for its soldiers to maintain.

Despite TRADOCs' best efforts, the army's ability to train new soldiers on the maintenance of sophisticated warfighting technologies remained a problem. To achieve success in Operation Desert Storm, the US Army relied on civilian maintenance contracts for the bulk of the M1A1 tank services in Kuwait; in some instances, maintenance contractors moved with tactical units.[75] In the 24th Infantry Division, maintenance teams worked more than twelve hours per day to keep the operational readiness rate above ninety percent.[76] Furthermore, the US Army did not possess the skilled technicians required to repair many platforms' "black boxes" in the combat theater; shipping those parts back to America for repair required time and money.[77] As Major General Gorman predicted, the technological advances to combat equipment outpaced the

[72] James Vaughan, Brian Silbernagel, and Stephen Goldberg, *M1 Abrams Tank Procedure Guides* (Alexandria, VA: US Army Research Institute, 1982), 1-2, accessed 02 September 2020, https://apps.dtic.mil/dtic/tr/fulltext/u2/a144427.pdf.

[73] Ibid., 2.

[74] Ibid., 7-8.

[75] Donald Wright and Timothy Reese, *On Point II: The Transition to a New Campaign* (Leavenworth, KS: Combat Studies Institute Press, 2008), 493.

[76] Kitfield, *Prodigal Soldiers*, 393.

[77] Verdugo and Babin, *Impact of Advanced Technology*, 13.

training programs developed to maintain and repair that equipment.[78] The US Army became dependent on outside expertise because it could not train enough soldiers to master the requisite maintenance skills.

Information Age Capabilities – The Virtual Continuum

New tools now exist to help the US Army efficiently train soldiers at the point-of-need, presenting opportunities for resilient training strategies that rely less on outside civilian expertise. One of those tools, augmented reality, belongs to a broader technology area that most people confuse with virtual reality.[79] Therefore, a short review of the taxonomy to clarify technological capabilities is necessary before discussing what augmented reality brings to the US Army's training environment.

The virtual continuum consists of a spectrum of environments. Paul Milgram, an expert in human-machine interfaces, explains the virtual environment resides at one end of the spectrum, and the real environment resides at the other end of the spectrum.[80] Virtual reality exists in the virtual environment, an environment where users do not interact with the physical world around them, only the synthetic environment.[81] Augmented reality, however, superimposes virtual objects onto the real environment to enrich and complement the real environment, allowing users to interact with both the real and virtual environment.[82] With virtual reality, a computer system generates the environment to stimulate the user through an immersive sense of sight, touch, and

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[78] Verdugo and Babin, *Impact of Advanced Technology*, 11.

[79] Mark A. Livingston et al., "Military Applications of Augmented Reality," in *Handbook of Augmented Reality* (Washington, DC: Naval Research Laboratory, 2011), 3.

[80] Paul Milgram and Fumio Kishino, "A Taxonomy of Mixed Reality Virtual Displays," *IEICE Transactions on Informations and Systems* E77-D, 12 (December 1994): 1321-1329, accessed 01 September 2020, https://www.researchgate.net/publication/231514051_A_Taxonomy_of_Mixed_Reality_Visual_Displays.

[81] Gabriela Kiryakova, Nadezhda Angelova, and Lina Yordanova, "The Potential of Augmented Reality to Transform Education into Smart Education," *TEM Journal* 7, no. 3 (2018): 559, accessed 28 August 20, https://dx.doi.org/10.18421/TEM73-11.

[82] Ibid., 559-560.

hearing.[83] In virtual reality, the user is detached from the real environment and loses awareness of what occurs around them, using visualization goggles, haptic gloves, and headphones to create an immersive and virtual experience.[84]

Augmented reality differs in important ways from virtual reality, and did not merely evolve as a technology. Augmented reality allows users to remain aware of their surroundings, interact with real-world objects, and receive digital aids that increase users' interactive experience. Augmented reality can use a heads-up display (HUD), mobile devices, or other devices with cameras to overlay digital content onto the real environment.[85] Three main characteristics of augmented reality include the combination of real and virtual environments, the ability to interact with an object in real-time, and the object's registration three-dimensionally.[86] An initial understanding of this taxonomy furthers US Army leaders' discussion about training aids such as the Synthetic Training Environment, virtual reality, and augmented reality. Augmented reality exists as a tool within the Synthetic Training Environment and functions independent from simulators and virtual reality.

Training Delivered to the Point-of-Need

US Army institutional schools often trail the operational force in training new warfighting technologies. In 1976, Major General Gorman boldly stated that schools "always lagged behind" the operational force since the profession changes so fast.[87] To address this concern, the 2013 TRADOC commander General Robert W. Cone suggested using emerging technologies to deliver training at the point-of-need, thereby mitigating the lag between

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[83] Manuel Fernandez, "Augmented Virtual Reality: How to Improve Education Systems." *Higher Learning Research Communications* 7, no. 1 (2017): 2-3, accessed 28 August 2020, http://search.ebscohost.com.lumen.cgsccarl.com/login.aspx?direct=true&db=eric&AN=EJ1150087&site=ehost-live&scope=site.

[84] Ibid.

[85] Ibid.

[86] Ibid.; Fidan and Tuncel, "Augmented Reality in Education," 578.

[87] Gorman, "Presentation Armed Forces Staff College," 22.

institutional schools and the operational force.[88] Augmented reality emerged as one of the most recent technologies that can minimize the knowledge gap between equipment fielding and institutional schools. Augmented reality generates remembered hands-on training for soldiers, personalizes training based on skill level and aptitude, and accelerates the knowledge transfer rate of technical information compared to legacy training methods, thereby delivering practical point-of-need training.

Providing Hands-On Training

NCOs currently provide hands-on training to mitigate the lag in institutional training; however, the current systems reduce training quality for new soldiers. New soldiers often miss point-of-need training since operator new equipment training (OPNET) and field-level maintenance new equipment training (FLMNET) typically align with initial equipment fielding, not personnel manning cycles. Although these programs produce results, civilian trainers have a finite amount of time and rarely return. Even when civilian trainers certify an NCO as a trainer, the NCO rarely remains in a unit for more than three years based on army personnel policies. New soldiers arrive monthly, and units do not afford NCOs dedicated time to provide the same hands-on training provided by the OPNET or FLMNET. Augmented reality, combined with NCO trainers, provides new soldiers with ongoing hands-on training and instruction instead of leftover manuals or slide presentations provided by the OPNET or FLMNET team.

As follow-on training to OPNET or FLMNET, units improve training quality by training soldiers at the point-of-need where they apply their technical skill set. Augmented reality

[88] General Robert W. Cone, "Building the New Culture of Training," *Military Review* 93, no. 1 (January-February 2013): 14, accessed 14 September 2020, http://cgsc.contentdm.oclc.org/cdm/ref/collection/p124201coll1/id/1191.

provides a hands-on student-centered learning environment at the point-of-need.[89] Figure 1 demonstrates how a soldier uses augmented reality to receive hands-on technical training inside a LAV-25 armored personnel carrier, a method that researchers found thirty-seven percent faster than the use of computer screens.[90] The picture on the left side of Figure 1 shows a marine wearing an augmented reality HUD. The picture on the right side of Figure 1 shows what the marine sees through the HUD. The marine sees the equipment he needs to repair, white text at the top providing instructions, the nomenclature of the item in yellow, and a picture of the socket with 3D images in yellow showing the bolt that needs removal.

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Figure 1. Augmented Reality Hands-On Overlay. Steven J. Henderson and Steven Feiner, "Evaluating the Benefits of Augmented Reality for Task Localization in Maintenance of an Armored Personnel Carrier Turret" (paper presented at the *2009 8th IEEE International Symposium on Mixed and Augmented Reality, Orlando, FL, 19-22 October 2009)*, 135, accessed 13 September 2020, https://graphics.cs.columbia.edu/projects/armar/pubs/henderson_feiner_ismar2009.pdf. The photo on the right side of Figure 1 is substituted from a different domain since the actual view through the heads-up display was not cleared for publication due to security restrictions.

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[89] D.R. Robert Joan, "Enhancing Education through Mobile Augmented Reality," *Journal of Educational Technology* 11, no. 4 (2018): 10, accessed 28 August 2020, http://search.ebscohost.com.lumen.cgsccarl.com/login.aspx?direct=true&db=eric&AN=EJ1098600&site=ehost-live&scope=site; Mustafa Sirakaya and Ebru Kilic Cakmak, "Effects of Augmented Reality on Student Achievement and Self-Efficacy in Vocational Education and Training," *International Journal for Research in Vocational Education and Training* 5, no. 1 (2018): 2, accessed 28 August 2020, http://search.ebscohost.com.lumen.cgsccarl.com/login.aspx?direct=true&db=eric&AN=EJ1178349&site=ehost-live&scope=site.

[90] Steven J. Henderson and Steven Feiner, "Evaluating the Benefits of Augmented Reality for Task Localization in Maintenance of an Armored Personnel Carrier Turret" (paper presented at the *2009 8th IEEE International Symposium on Mixed and Augmented Reality, Orlando, FL, 19-22 October 2009)*, 135-144, accessed 13 September 2020, https://graphics.cs.columbia.edu/projects/armar/pubs/henderson_feiner_ismar2009.pdf.

Augmented reality enables inexperienced soldiers to conduct hands-on technical training while simultaneously completing tasks on which their unit leadership did not formally train them. Augmented reality software uses image recognition to place technical manual instructions on the HUD while generating digital overlays on actual equipment. The overlay of information and instructions reduces the cognitive overload by providing learning through interaction with the real environment instead of reducing the new soldier to the status of a spectator.[91] Even if the soldier received formal training, augmented reality reinforces training with hands-on training beyond OPNET or FLMNET programs. Furthermore, it presents information that an instructor may have failed to cover due to oversight or lack of time.

Like training with an instructor, augmented reality provides an interactive experience at the point-of-need through multiple sensory devices, thereby improving skill retention and task proficiency. Although OPNET and FLMNET trainers provide some personalized feedback, augmented reality provides constant personalized feedback during hands-on training. In addition to visual and audible cues, the integration of vibrotactile bracelets with augmented reality provides haptic cues to the soldier.[92] Software designers can program various cues to reinforce correct actions or warn against incorrect procedures. The ongoing interaction with augmented reality provides a personalized, hands-on experience at the point-of-need.

Providing Personalized Training

Augmented reality provides interactive, personalized, learner-centric training, and feedback for the individual based on skill level and aptitude. Major General Gorman emphasized that the US Army's most significant opportunity for winning was through individual training.[93]

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[91] Joan, "Enhancing Education," 10; Fernandez, "Augmented Virtual Reality," 1-15.

[92] Sabine Webel et al., "An Augmented Reality Training Platform for Assembly and Maintenance Skills," *Robotics & Autonomous Systems* 61, no. 4 (2013): 399-400, accessed 28 August 2020, https://doi.org/doi:10.1016/j.robot.2012.09.013.

[93] Gorman, "Presentation Armed Forces Staff College," 4.

However, the Sustainable Readiness Model and the new Regionally Aligned Readiness and Modernization Model do not account for individual soldiers who enter a training cycle at different times with different skill sets and training. Augmented reality provides an opportunity to personalize training to individual skill level and aptitude, thereby meeting them at their current skillset within existing US Army training models.

Augmented reality customizes training to the user's skill level and tracks progress at the point-of-need. Learner-centered training enhances intrinsic motivation and allows soldiers to progress at their own pace.[94] Training schedules, standardized training, and lack of instructors are reasons soldiers train at different rates. The complexity of new technologies requires so many niche instructors that the US Army must rely on the commercial sector for training assistance, which results in broad standardized training and fails to address personal expertise and skill level.[95] With augmented reality, trainers increase their ability to track an individual soldier's progress, and soldiers can customize training to their current skill level.

In addition to tracking progress and personalization, augmented reality allows the soldier to customize how they receive information. Figure 2 shows an example of augmented reality used as a customized and personalized training aid. The left picture in Figure 2 demonstrates more robust guidance and three-dimensional visual aids for the less experienced. As soldiers progress in their technical skills, they can adjust the guidance level and remove robust guidance. The right picture of Figure 2 displays reduced guidance levels with fewer instructions and two-dimensional overlays. Users configure their HUD user profiles to remember both settings and preferences.

[94] Livingston et al., "Applications of Augmented Reality," 5-25.

[95] Verdugo and Babin, *Impact of Advanced Technology*, 10.

Figure 2. Augmented Reality Personalized Training. Sabine Webel et al., "An Augmented Reality Training Platform for Assembly and Maintenance Skills," *Robotics & Autonomous Systems* 61, no. 4 (2013): 399, accessed 28 August 2020, https://doi.org/doi:10.1016/j.robot.2012.09.013.

Augmented reality also provides soldiers the ability to experiment in a virtual maintenance environment and test their technical skill level. Soldiers interact with augmented reality to practice maintenance requirements on a virtual model of the equipment before making the actual repair.[96] Using a virtual model allows the soldier to manipulate the object in ways that make sense to them individually. The soldier can change the virtual object's position, size, shape, or even take it apart virtually and reassemble it.[97] This experimentation provides feedback to the soldier before making a costly mistake and helps the soldier personalize an approach to the repair.

Interactive feedback also allows soldiers to exchange ideas within a network of geographically dispersed soldiers, enhancing their personalized learning experience. Soldiers can securely share their view through the HUD with other soldiers who are not at the same location.[98] This connection provides another option for interactive feedback and reduces the social isolation that digital systems can exacerbate. The connection also allows for advanced technical feedback from subject-matter experts and trainers who expand troubleshooting options. This capability

[96] Joan, "Enhancing Education," 11.

[97] Kiryakova, Angelova, and Yordanova, "Potential of Augmented Reality," 561.

[98] Joan, "Enhancing Education," 11.

creates an open-source resource with other soldiers and leaders across the US Army, providing personalized solutions at the point-of-need.

Accelerating the Transfer of Knowledge

Finally, augmented reality accelerates the knowledge transfer rate of technical information, compared to legacy training models, to increase point-of-need training effectiveness. Cognitive psychology measures the transfer of learning by how fast the learning of one task facilitates learning a second task.[99] When related to technical skill training, knowledge transfer measures how much technical training a soldier applies to the job and how the transfer impacts later job performance.[100] Various studies have measured knowledge transfer through augmented reality with promising results and suggest increased technical skill effectiveness.

Within the augmented reality experience, soldiers actively observe and explore the environment, increasing learner achievement faster than other training methods. Cognitive psychologists and studies have various opinions on why augmented reality accelerates the rate of knowledge. However, studies have confirmed that augmented reality increases the amount of information a soldier can process from training experiences.[101] While a picture is worth a thousand words, it is plausible that an experience conveys thousands of pictures and a more holistic learning environment.

Both inexperienced and experienced technicians can improve their cognitive processing skills and knowledge transfer of technical information with augmented reality. Researchers studied the impact of augmented reality on specialized and highly trained technicians. In a 2018 study, researchers focused on technicians who maintained a Boeing 737 engine bleed air system.

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[99] Eduardo Salas et al., "The Science of Training and Development in Organizations: What Matters in Practice," *Psychological Science in the Public Interest* 13, no. 2 (2012): 77, accessed 28 August 2020, www.jstor.org/stable/23484697.

[100] Salas et al., "What Matters in Practice," 77.

[101] Fernandez, "Augmented Virtual Reality," 3.

Compared to printed technical manuals, technicians who used augmented reality were seventeen percent faster at assembling the bleed air system and improved twenty-four percent in quality by reducing errors.[102] With faster knowledge transfer, soldiers will complete maintenance requirements faster, reduce errors, and mitigate risk during individual and collective training.

Accelerated knowledge transfer of technical information creates efficiency in the learning process and provides more quality time for collective training. Since augmented reality provides soldiers a tool used at the point-of-need, it does not require as much dedicated time on the training schedule. Although commanders must balance individual training with collective training, augmented reality allows soldiers to learn the technical skills not achieved during formal train-up to collective training. Faster knowledge transfer of technical information also benefits the US Army Reserve, which historically lacked adequate training time to maintain and repair complex weapons systems.[103] Finally, the efficiencies gained enable a faster train-up for Individual Ready Reserve (IRR) soldiers, allowing them to participate in collective training or combat operations sooner than traditional methods.

Augmented reality minimizes the knowledge gap between inexperienced soldiers and sophisticated weapon system maintenance requirements by providing hands-on training, personalized training, and accelerated knowledge transfer of technical information at the point-of-need. Whether at peace or in conflict, the operational force cannot rely on the generating force to send expert maintenance technicians to the force. Even Ardant du Picq knew soldiers would not come to a battalion adequately trained to use the lance.[104] On-the-job training remains a critical component of learning technical skills, which must occur in a future LSCO environment.

[102] Horacio Rios et al., "A Mobile Solution to Enhance Training and Execution of Troubleshooting Techniques of the Engine Air Bleed System on Boeing 737," *Procedia Computer Science* 25, no. 1 (2018): 164-168, accessed 13 September 2020, https://dx.doi.org/10.1016/j.procs.2013.11.020.

[103] Kitfield, *Prodigal Soldiers*, 352; Vaughan, Silbernagel, and Goldberg, *Abrams Tank Procedure Guides*, 6.

[104] Ardant du Picq, *Battle Studies*, 112.

Augmented reality provides on-the-job training to the point-of-need while mitigating some realistic training gaps between the generating force and the operational force's maintenance requirements.

Increasing Efficiency

US Army maintenance training requirements will likely continue to grow as it competes with near-peer adversaries. Furthermore, the US Army will undoubtedly continue to introduce new and increasingly sophisticated weapon systems. While a new weapon system may provide an advantage or even an offset, it will quickly grow irrelevant if soldiers do not know how to maintain it. The US Army needs to balance training for maintenance skills with individual training and collective integration and employment of battlefield capabilities.[105] The amount of dedicated time to train individual skills remains a well-known challenge, requiring the US Army to find new efficiencies.

Maintenance requirements continue to grow, and the time to complete maintenance tasks remains the same, making maintenance efficiency even more critical. In 1962, the 3rd Battle Group 6th Infantry commander, Colonel Samuel H. Hays, told Major General Ben Harrell, Commandant of the US Army Infantry School, that the time devoted to just maintenance had doubled in the previous decade.[106] In 1979, General Starry articulated a "hostile" peacetime training environment that threatened the extra training time required for new warfighting technologies.[107] Maintenance requirements will continue to expand in scope during LSCO. If personnel requirements exceed the AVF capacity, inexperienced soldiers must join the formation under the most efficient training method feasible.

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[105] Verdugo and Babin, *Impact of Advanced Technology*, 10.

[106] Linn, *Elvis's Army*, 310. Linn quotes Colonel Hays' correspondence to Major General Harrell which he found in Box 82, Entry Number UD-9 Records of US Army Continental Army Command.

[107] Starry, *Press On*, 706.

Individual and collective training requirements increasingly constrain today's training environment. In 2015, the US Department of the Army G-3/5/7 staff tried to frame the problem by showing only 220 days available to generate readiness and over 366 days of training required.[108] Even their attempt to frame the problem showed gross inaccuracy by only allocating thirty-four days of command maintenance per year.[109] In reality, a single Stryker Battalion requires over eighty days per year for semi-annual and annual services, not including unscheduled maintenance, commodity weapon services, and communication system services.[110] Those same operators and maintenance technicians also participate in much of the same individual and collective training. The required balance of maintenance and mission-essential training highlights the need for methods and aids that cross-train soldiers on low-density and high-demand technical skill sets.

Major General Gorman defined training efficiency as a combination of weapon systems capability, tactics or techniques by which units employ the weapon, and the soldier proficiency on the weapon system.[111] The individual soldier's proficiency includes an ability to maintain their equipment. Although soldiers obtain some maintenance proficiency through formal training, augmented reality increases the soldier's motivation to learn, unit training programs' effectiveness, and acquisition of the technical skills required to repair sophisticated weapon systems, thereby improving training efficiency.

[108] David Pidone, "Making Sustainable Readiness Sustainable for the Army National Guard" (Strategy Research Project, US Army War College, Carlisle, PA, 2018), 10, accessed 21 October 2020, https://publications.armywarcollege.edu/pubs/3583.pdf.

[109] Ibid.

[110] Semi-Annual and Annual Services were calculated using the 2020 Modification Table of Organization and Equipment for the 2nd Cavalry Regiment and the Maintenance Allocation Charts provided in the respective Technical Manuals. Commodities such as weapons, communication equipment, and CBRN-E were not factored into the calculation.

[111] Gorman, "Presentation Armed Forces Staff College," 6.

Increasing the Motivation to Learn

Information-age training aids, such as augmented reality, improve soldier training motivation and efficiency through an interactive maintenance experience. The trainer, or training aid, adds to only part of the equation; the soldier completes the other part. Since the quality and quantity of learning are proportional to the amount of effort a soldier invests, trainers need to know what motivates soldiers to learn.[112] In many cases, motivation comes from an interactive training environment. Unfortunately, many military and civilian trainers are still using industrial-age training paradigms that do not involve interactive environments. Other methods and aids exist, such as augmented reality, which supports information-age training paradigms.

Although industrial-age training works, it is not as effective as information-age training and tools. Current research suggests that many instruction models employ industrial-age training techniques for information-age students. Industrial-age training presents a problem since it struggles to engage and retain the attention of soldiers.[113] The results achieved by using old training models do not indicate that soldiers do not learn, but rather that soldiers do not intrinsically engage the material; they learn more slowly and retain less than students trained with augmented reality. The use of printed instruction, diagrams, and other printed schemes take longer for trainees to learn and only allows for passive knowledge transfer of technical information.[114] The use of these static materials explains why industrial-age training paradigms historically use extrinsic motivation such as grades, failing a course, or repeating a course to force engagement on the trainee.[115] Information-age training models seek more intrinsic motivation than industrial-age models.

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[112] Charles M. Reigeluth, "An Instructional Theory for the Post-Industrial Age," *Educational Technology* 51 (October 2011): 25, accessed 28 August 2020, www.jstor.org/stable/44429947.

[113] Kiryakova, Angelova, and Yordanova, "Potential of Augmented Reality," 556.

[114] Ibid., 561; Sirakaya and Cakmak, "Effects of Augmented Reality," 3.

[115] Reigeluth, "Instructional Theory," 25.

Intrinsically motivated soldiers find training more enjoyable and are more likely to engage in the material. Augmented reality allows soldiers' input to design their training, increase their motivation, and personalize the training.[116] The ability to personalize augmented reality engages the soldier in constructivist learning.[117] In addition to personalizing, soldiers can communicate with subject matter experts or facilitators through augmented reality, receiving advanced personal instruction when needed.[118] Personalizing training increases the chances that a soldier engages in more training material and applies it to what they already know, looking for other ways to complete maintenance requirements and solve technical problems.

A study by USAF Air Education and Training Command highlighted that personnel found training more enjoyable with augmented reality. In the 2011 study, sixty-three percent of C-130 loadmaster students stated that augmented reality provided better training than checklists and class discussion.[119] The instructors also unanimously agreed that augmented reality improved the training experience.[120] Although anecdotal, this study highlights information-age training paradigms can increase military personnel's motivation.

Augmented reality increases soldiers' motivation to learn, which can increase the initiative to act. As the US Army balances collective and individual training, augmented reality provides intrinsic motivation for soldiers at the individual level. If soldiers enjoy using augmented reality as an aid, they are more likely to self-initiate action and begin to learn as part of a reflection-on-action process. Self-motivation remains critical for soldiers in a fast-paced environment where direct supervision does not always exist.

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[116] Kiryakova, Angelova, and Yordanova, "Potential of Augmented Reality," 558; Salas et al., "What Matters in Practice," 78.

[117] Fidan and Tuncel, "Augmented Reality in Education," 585.

[118] Fernandez, "Augmented Virtual Reality," 13.

[119] Livingston et al., "Applications of Augmented Reality," 8-9.

[120] Ibid.

Increasing Effectiveness

In addition to motivation playing an essential role in maintenance effectiveness, augmented reality improves effectiveness by reducing repair time and errors. Reduced error rates save the US Army money, and faster repair times equate to more collective training. In 2013, General Cone stated a foundational imperative for the Army of 2020 was to harness technology that enabled faster and more efficient training.[121] Cone believed that TRADOC owed commanders the tools to help them train more efficiently in almost any environment while moving beyond the industrial-age paradigms like field tables or 100-slide presentations.[122] Not even a full decade later, the US Army has the potential to implement the type of technology that Cone might have envisioned. Augmented reality software upgrades to IVAS hardware reduces reliance on printed technical manuals and shortens repair time.

Augmented reality reduces maintenance repair time compared to maintenance personnel using paper technical manuals. In one study using armored military vehicles, researchers found mechanics were thirty-seven percent faster using augmented reality instead of computer screens, which was statistically significant.[123] Researchers from different groups attribute this to using a head-worn display that allows mechanics to locate tasks faster based on a natural view of the text, arrows, and animated instructions present in the HUD, reducing head movement and orientation between manuals and the task at hand.[124] Other researchers explain that manuals often contain unnecessary information about the assembly or repair of an item, which forces the mechanic to slow down and study the item as the mechanic tries to orient themselves.[125]

[121] Cone, "New Culture of Training," 11.

[122] Ibid., 14.

[123] Henderson and Feiner, "Task Localization in Maintenance," 140.

[124] Ibid., 135.

[125] Sirakaya and Cakmak, "Effects of Augmented Reality," 2-3.

Augmented reality also increases assembly speeds. Numerous civilian researchers studied augmented reality, examining similar efficiencies that increased maintenance and assemblage requirements.[126] In one study, participants assembled two-dimensional and three-dimensional puzzles with augmented reality and a different set of puzzles with a computer monitor instead of augmented reality. The trainees using augmented reality assembled the puzzles faster.[127] Another study required seven engineer students to assemble twelve parts of an RV-10 aircraft, of which they had no prior experience.[128] All of them showed a faster assembly time when assisted with augmented reality, compared to traditional manuals.[129]

As the US Army increases weapon system sophistication and "black box" technology, maintenance technicians will need to repair complex end items and components rapidly and correctly in a combat theater instead of waiting for a replacement to show up. Numerous studies have shown improved circuit board repair with the use of augmented reality. One study showed that aircraft motor mechanics were seventeen percent faster and increased twenty-four percent in quality assurance.[130] Another study used electrical motherboard assemblies and discovered that participants using augmented reality completed assembly sixty percent faster than other participants.[131] Finally, another study shows fifty percent fewer assembly errors, and participants were twenty percent faster in electrical motherboard assembly.[132] As "black box" technology

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[126] Webel et al., "Augmented Reality Training Platform," 398.

[127] Stefan Werrlich et al., "An Overview of Evaluations Using Augmented Reality for Assembly Training Tasks," *World Academy of Science, Engineering and Technology, International Journal of Computer, Electrical, Automation, Control and Information Engineering* 11, no. 10 (2017): 1080-1086, accessed 13 September 2020, https://publications.waset.org/10007977/an-overview-of-evaluations-using-augmented-reality-for-assembly-training-tasks.

[128] Fernando Suárez-Warden et al., "Assembly Operations Aided by Augmented Reality: An Endeavour Toward a Comparative Analysis," *Procedia Computer Science* 75, no. 1 (2015): 281-290, accessed 13 September 2020, https://dx.doi.org/10.1016/j.procs.2015.12.249.

[129] Ibid.

[130] Sirakaya and Cakmak, "Effects of Augmented Reality," 4.

[131] Ibid., 4-5.

[132] Ibid., 5.

becomes more pervasive in the US Army, it will require faster and higher quality repair in an expeditionary environment.

Increasing Maintenance Skill Retention

Soldiers retain long-term skills with augmented reality usage, increasing maintenance training benefits and efficiency. Much like the relationship between a compass and a global positioning system, soldiers need to retain maintenance skills if augmented reality loses power, encounters data corruption, or breaks. For maintenance technicians, skill-building and retention are equally critical based on historical lessons. In 1976, Major General Gorman lamented how thirty-eight percent of the parts removed by Skill Level 2 maintenance technicians were in mint condition.[133] The underlying problem consisted of a lack of training and leadership oversight. The motor sergeant was simply passing the technical manual to the soldier.[134] While the emphasis on leadership persists, the motor sergeant cannot stand over every Skill Level 2 mechanic's shoulder. Augmented reality does not eliminate a leader; instead, leaders remain available at the right time and location. When the Skill Level 2 mechanic encounters a problem, it still allows the mechanic to ask a motor sergeant or warrant officer for assistance.

Unlike a technical manual, augmented reality helps mechanics interactively explore the problem, enabling skill retention through knowing-in-action. Much like the constructivist learning model, augmented reality provides a knowing-in-action that can increase recognition of right or wrong based on repetition, primarily when paired with haptic cues.[135] The soldier's reflective interaction with items they are repairing enables them to reveal they know more than they believe. It also gives them the ability to experiment and simulate the repair before confidently

[133] Gorman, "Presentation Army War College," 25.

[134] Ibid.

[135] Donald A. Schoen, *Educating the Reflective Practitioner* (San Francisco: Jossey-Bass, 1987), 23-38.

executing. The hands-on experimentation allows the soldiers to shape their own learning experience instead of observing others.[136]

The soldier's experimentation, if enabled by augmented reality, can provide longer skill retention in memories. One study required participants to learn the assembly procedure for an oil pump through different methods such as printed manuals, video, and augmented reality. The researchers found that participants who used augmented reality performed better in both short-term and long-term memory applications. Another study involved ninety-six participants who studied aircraft major assembly items in four separate groups. Participants remembered skills over a long period in every group when they used augmented reality-enabled tools instead of print and video.[137] Much of this research demonstrated significantly better long-term recall when compared to print and video-based training. Much like motivation and information-age paradigms, the student performed better when interacting with the training material.

Resilient Training Strategies

While the US Army prepares to fight the first battle and win, senior leaders cannot ignore a historical fact that every army loses at some point. If the US Army loses enough battles, the country will likely need to rapidly mobilize and train replacements. Not all replacements possess military experience, and many replacements will likely receive training in unfamiliar skills, to include maintenance. Therefore, senior leaders need to ensure they already have a supportive cognitive environment in place for training replacements on sophisticated equipment maintenance.

TRADOC leaders who concern themselves with training and maintaining highly-skilled soldiers must also focus on future maintenance training strategies. In a 1989 keynote address to a group of forecasters, Major General William H. Reno, then Director of the Army's Programs,

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136 Schoen, *Educating the Reflective Practitioner*, 68, 322.

137 Werrlich et al., "Evaluations Using Augmented Reality," 1130-1132.

Analysis, and Evaluation Directorate, stated that 2020 would require high-tech skills based on growing sophistication in warfighting technologies.[138] While a lot changed since 1989, Reno accurately described a future operating environment that will grow even more sophisticated in another thirty years and require training strategies that meet the technical demands. If requirements exceed the All-Volunteer Force capacity, augmented reality mitigates skill shortages, minimizes expansion of existing infrastructure, and increases full system design capability, thereby creating a resilient training strategy.

Mitigating Skill Shortages

Augmented reality can mitigate skill shortages in combat operations. Historically, the US Army has cross-leveled Military Occupation Specialties (MOS) and cut institutional training time. During the 1990 Gulf War, TRADOC prepared for a training expansion of over 75,000 members from the IRR.[139] Operations Desert Shield and Desert Storm demonstrated that the IRR needed serious refresher training for critical shortages such as 88M, a motor transport driver.[140] As a result, FORSCOM quickly diverted soldiers from their original MOS to fill the shortage and shortened an eight-week course to four weeks.[141] In the future, augmented reality can cross-train soldiers already present within the force, leveraging talent and providing training with augmented reality.

Augmented reality enables cross-leveling of new skills and increases the interoperability of soldiers and units. As technology advances, combat personnel have decreased, and noncombat MOSs with niche maintenance skills have increased.[142] This increase in niche skills has dispersed

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[138] Major General William H. Reno, "Program Projection in a Dynamic Environment," (keynote address given at the Second Annual Federal Forecasters Conference, Washington, DC, 06 September 1989), 3-5, accessed 19 September 2020, https://cer.columbian.gwu.edu/sites/g/files/zaxdzs2011/f/downloads/FFC1989.pdf.

[139] Romjue, Canedy, and Chapman, *Prepare the Army*, 132-33.

[140] Ibid.

[141] Ibid.

[142] Verdugo and Babin, *Impact of Advanced Technology*, 2-6.

specially trained soldiers across an enormous battlefield and area of combat.[143] The soldier required to complete a particular task will not always be present when and where the unit needs them. Soldiers, who use augmented reality, retain a working knowledge of problems they encounter and build redundancy within maintenance teams. As a result, soldiers learn to perform repairs outside of their original skill set.

As soldiers backfill new skills, they can use augmented reality to learn basic tasks and sub-tasks. Enhancements, such as incorporating haptic gloves, allow soldiers to learn motor patterns through repetitions in augmented reality before executing the task in the real world.[144] Soldiers can also see the assembly steps overlaid directly on the hardware instead of studying a two-dimensional piece of paper.[145] When the soldier reaches a problem they cannot solve, they can reach back through the augmented reality hardware for a technician to assist with the specific problem.[146] This technology provides a basic level of instruction to soldiers who do not possess formal training.

Direct leaders also benefit from augmented reality as they take responsibility for new weapons systems in the formation. *Army Leadership and the Profession* requires organizational leaders to know how their equipment works and remain technically competent, while the direct leader is a technical expert.[147] Direct leaders struggle to exhibit technical expertise on all weapon systems based on how often they change units and encounter new equipment. Augmented reality can augment existing training strategies, thereby providing resiliency to shortened or unavailable institutional training.

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[143] Verdugo and Babin, *Impact of Advanced Technology*, 2-6.

[144] Webel et al., “Augmented Reality Training Platform,” 500-501.

[145] Sirakaya and Cakmak, “Effects of Augmented Reality,” 14.

[146] Ibid.

[147] US Army, ADP 6-22, 9.

Minimizing Expansion of Infrastructure

Augmented reality minimizes the expansion of two infrastructure types, physical structures and civilian contractor requirements. Both structures and civilian contractors for maintenance increase operational footprints and require finite resources like money, space, security, and time. Specifically related to training, General Starry observed that technology could overcome the high cost of training readiness.[148] Many of those costs came from range use, physical space, and contractor support. As training technology improved and shifted to simulators, General Cone observed that digital training could provide low overhead costs at the point-of-need without paying for large simulation centers.[149] As technology improves, Cone's comments also apply to maintenance training. Augmented reality reduces further expansion of maintenance overhead costs and lowers future overhead costs by training soldiers at the point-of-need and expanding current talent in the force.

As part of institutional training, augmented reality allows soldiers to practice without hands-on training risks and costs. Augmented reality allows the soldier to display an image of the object they repair over real space, without needing the physical equipment to complete the process.[150] Practicing sensitive repairs on a three-dimensional image saves the US Army time and money from damage that an inexperienced soldier may make. A quick practice iteration with augmented reality may determine how much combat power remains available for a commander during combat operations. While soldiers have always been able to train almost anywhere, creatively, augmented reality provides realistic hands-on training that does not require bay space or large vehicles. Hands-on training occurs anywhere a soldier is allowed to take their augmented reality.

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[148] Starry, *Press On*, 215.

[149] Cone, "New Culture of Training," 16.

[150] Fernandez, "Augmented Virtual Reality," 5.

Augmented reality can help reduce the scope of civilian contractors. Contracted maintenance support continues its growth in the US Army. The start of Operation Iraqi Freedom in 2003 saw thirty percent of combat systems serviced by contracted maintenance, not counting the new Stryker brigades that were not yet part of the Army life-cycle.[151] Nor did that account for increasing contractor support resulting from commercial-off-the-shelf equipment and newly-fielded systems. While contracted maintenance may have previously worked, it increases risk by presenting lucrative targets and critical vulnerabilities. Augmented reality enables soldiers to repair the equipment forward and reach back virtually to contracted maintenance as needed, reducing the battlefield's logistical infrastructure.

Increasing Full System Design Capability

The use of augmented reality increases the odds that soldiers employ weapons systems to their full design capability. General Starry astutely observed that the standard maintenance unit consisted of less than fifty-four percent of maintenance personnel performing maintenance tasks.[152] The non-commissioned officers executed numerous other responsibilities, and supervision was often perfunctory, merely making sure that the vehicle ran.[153] As a result, preventive maintenance and essential fault detection rested on the least technically qualified soldier in the maintenance chain.[154] Augmented reality increases quality assurance and expands knowledge to more operators. Therefore, units reach full design capability by using augmented reality with soldiers that are not mechanics and incorporating more soldiers into the maintenance system.

Augmented reality can mitigate compressed training cycles that prevent proper training standards. Future training will be far more condensed than in the 1970s. During the 1970s, most

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[151] Wright and Reese, *On Point II*, 408-409, 517.

[152] Starry, *Press On*, 524.

[153] Ibid.

[154] Ibid., 523.

soldiers in their first enlistment never fired a full gunnery qualification, let alone conducted maintenance during high operational tempo events. Major General Gorman summed it up best when he stated that the US had "an army of neophyte tankers" that would have to face Soviet forces in Germany.[155] Augmented reality can assist in both simulating and executing maintenance training. It also provides concurrent training opportunities at the point-of-need, ensuring sophisticated weapons, such as the tank, stay in the fight.

The use of augmented reality can also mitigate training shortfalls for the National Guard. The US Army may not have had as many neophyte tankers in the 1990 Gulf War, but it certainly discovered gaps in readiness with the National Guard. The 48th Infantry Training Brigade was so ill-prepared at the National Training Center (NTC) that leaders relieved General William Holland of command. The brigade remained at NTC for the longest known training rotation.[156] US Army leaders validated that soldiers will not rise to the event in combat but rather fall to the level to which they trained before the fight.[157] While Holland's readiness challenges expanded beyond maintenance training, the experience highlights the issues of rapidly pairing inexperienced soldiers with sophisticated weapon systems and then collectively training new skills. Augmented reality reduces some of the variables, especially within non-transferable technical skill sets.

Augmented reality reduces the amount of non-transferable technical skills within formations, thereby reducing dependency on specific individuals. A study by the US Army Research Institute cautioned that advanced technology led to increased MOS specialization, which means technical skills were quickly becoming non-transferable between soldiers.[158] While this also applies to cross-training, it is essential to note the vulnerabilities introduced with such specialization. Full weapon system maintenance becomes dependent on a few individuals. The

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[155] Gorman, "Presentation Army War College," 2.

[156] Kitfield, *Prodigal Soldiers*, 352.

[157] Romjue, *From Active Defense*, 67.

[158] Verdugo and Babin, *Impact of Advanced Technology*, 16.

alignment of skills and technology prevails as imperative for military organizations with increased technological sophistication. The US Army may purchase the hardware, but it will not be of use to anyone if no one can fix it.

Conclusion

On 04 December 1981, General Starry sent a letter to Charles C. Moskos Jr., a military sociologist and professor at Northwestern University, reflecting on new technologies like the Abrams tank and Bradley fighting vehicle. Starry stated, "I'm afraid the viability of the mass draft Army, or even of volunteer numbers recruited without strict regard to their smarts, may be a thing of the past for us—in any context, emergency or other."[159] In the post-Vietnam War period, senior leaders understood that complexity and professional skills increased with modernization and training methods adjusted with new maintenance requirements. As the US Army continues to modernize, leaders can simplify complexity by improving the soldiers' ability to maintain equipment on the battlefield. Incorporating augmented reality as part of future training methods simplifies the maintenance of new sophisticated weapon systems.

As the US Army Futures Command leaders continue to look at 2035 weapon systems, they need to emphasize sustaining the technologies developed. TRADOC and CASCOM must play a lead role in developing maintenance training and efficiencies in maintenance to support new warfighter technologies. Maintenance requirements in 2035 will likely consist of increased "black box" technology, circuit boards, robotics, and unmanned equipment that requires expeditionary repair forward. Units that cannot repair forward, with organic soldiers, hinder operational reach, culminate early, and increase risk, especially with contested supply chains.

Granted, US Army leaders must treat new technologies, like augmented reality, with skepticism. As General Starry told leaders at the US Army Command and General Staff College

[159] Starry, *Press On*, 719.

in 1979, technology alone will not win the next war and to say so is "pure unadulterated baloney."[160] However, modern war shows that fighting power provides the margin of victory, and today's fighting power is a combination of the soldier and technology.[161] Senior leaders expect our non-commissioned offers to advance their expert knowledge and skills as lifelong learners and professionals.[162] However, those same senior leaders acknowledge in doctrine that "…the equipment the modern soldier carries is more technologically advanced and requires knowledge, care and skill to employ successfully."[163] Despite more skill and knowledge requirements, senior leaders continue to place individual training responsibilities on the team leader, the most junior and inexperienced NCO. As TRADOC and CASCOM leaders focus on MDO, maximizing the human domain will be equally, if not more critical, than modernization.

Although it may seem like a paradox, technology aids in maximizing the human domain. One reason stems from the rapid growth of technology and the emphasis on the knowledge required for survival in an information-age era.[164] Civilian companies already capitalized on enhancing human capital through technology and leveraged augmented reality as a technological advantage. For example, leadership at Mercedes-Benz USA recently implemented augmented reality in training and technical support at 383 dealerships.[165] Mercedes-Benz mechanics use augmented reality to complete maintenance tasks until they require additional help, at which point they integrate teleconsultation with a technical expert.[166]

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160 Starry, *Press On*, 823.

161 Bacevich, *The Pentomic Era*, 154-156.

162 US Department of the Army, Training Circular (TC) 7-22.7, *The Noncommissioned Officer Guide* (Washington, DC: Government Publishing Office, 2020), 6-4.

163 Ibid., 1-20.

164 Thomas J. Prestella, "Bridging the Military Leadership Gap: Adapting Industrial Era Militaries for Knowledge Era Warfare" (Masters Monograph, School of Advanced Military Studies, US Army Command and General Staff College, Ft. Leavenworth, KS, 2019), 1-7.

165 Rachel Metz, "If You Own a Mercedes, HoloLens Might Be Used to Help Fix It," *CNN Business*, 09 September 2020, accessed 14 October 2020, https://www.cnn.com/2020/09/09/tech/hololens-mercedes-repair/index.html.

166 Ibid.

While numerous training methodologies and aids exist, augmented reality is unique in combining point-of-need training, improved training efficiency, and a resilient training strategy. Its adoption by the army will bridge the inexperience gap of newly-inducted or newly-enlisted soldiers, allowing them to engage in sophisticated weapon system maintenance immediately. As others have stated, augmented reality does not provide the turn-key solution to training; however, augmented reality does provide an enormous combat multiplier within a training strategy.[167] Fortunately, the US Army doctrine already supports the use of new technologies in training strategies. However, it does not explicitly account for augmented reality, except under the vast virtual training spectrum.[168] Within that spectrum, the US Army synthetic training environment cross-functional team and TRADOC's Program Executive Office Soldier demonstrated augmented reality capability exists with the new IVAS.

Future technologies remain unknown; however, the growth of maintenance training requirements is certain. Information-age technologies, such as augmented reality, allow the resilient scaling of training with emerging technologies such as the existing IVAS or other hardware versions. The following three facts should compel CASCOM and TRADOC to implement augmented reality into maintenance training requirements. First, augmented reality improves point-of-need training by generating remembered hands-on experiences for soldiers, personalizing curriculum based on skill level and aptitude, and accelerating the knowledge transfer rate of technical skills compared to legacy training models. Further, it improves training efficiency by increasing a soldier's motivation to learn, the effectiveness of unit training programs, and the acquisition of the technical skills required to repair sophisticated weapon

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[167] Fernandez, "Augmented Virtual Reality," 2.

[168] US Department of the Army, Field Manual (FM) 7-0, *Train to Win in A Complex World* (Washington, DC: Government Publishing Office, 2016), 2-17. Doctrine states "use virtual and constructive training environment to supplement, enhance, and complement live training," doctrine does not list augmented reality as part of the virtual continuum.

systems. Finally, it creates a resilient training strategy by mitigating skill shortages, minimizing the expansion of existing infrastructure, and increasing full system design capability.

As leaders anticipate in *The US Army in Multi-Domain Operations 2028,* units will likely operate "…dispersed for an extended period without continuous [or contiguous] support from higher echelons."[169] Failing to focus on improved maintenance training methods and aids for new sophisticated weapons induces higher risks of failure during LSCO or events that require a rapid increase of inexperienced soldiers. Inexperienced soldiers, who fight dispersed from continuous maintenance support, must possess the technical skills required to maintain sophisticated weapon systems in their forward positions. Without new forward-deployable maintenance training methods and aids, such as augmented reality, units risk proving du Picq correct once again.

[169] US Army, TRADOC Pamphlet 525-3-1, 19.

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