Air Force Lt. Col. Chris Power, deputy division chief of North American Aerospace Defense Command operations support, takes part in the Amalgam Eagle 16 tactical exercise between the U.S. and Mexico 27 July 2016 in Colorado Springs, CO. The three-day exercise aimed to strengthen information sharing and coopration in response to a simulation of an illicit cross-border flight. (Photo by Lisa Ferdinando)

Big Data War Games Necessary for Winning Future Wars

Maj. Mark Van Horn, U.S. Army

Advanced war games, not advanced weapon systems, will be the most promising technological investment for the future force.[1] Whether dominating cyberspace and the electro-magnetic spectrum or providing wide area security in a sprawling, impoverished megacity or beating back a belligerent's attempt to seize scarce fresh water or securing an ally's border, no advanced weapon will ever replace well-trained soldiers and adaptive soldiering. Since the rain of explosive steel in the First World War, the modern battlefield's lethality has placed a premium on adaptive soldiers and mission driven leaders. And no smart weapon algorithm or automated command and control system can obviate the soldier's need to learn the skill set of modern war in ever better war games and simulations. Innovations in the information and

cognitive sciences will pull war games into the era of big data and revolutionize how we prepare ourselves to win future wars (whether we know with whom we'll fight, where we'll fight or what those wars will be like).

The End of Weapons Technology

Keeping our edge with physical weapons development alone will be increasingly intractable for two key reasons: physical laws and proliferation. Physical weapons development is culminating because weapons technology has boundaries imposed by the laws of hard science.[2] There are simply walls which can't be scaled, even if you spend mountains of money.[3] Many of the truly revolutionary discoveries like combined arms maneuver, missiles, and drones have been invented. You can observe this technological plateauing in the changes in cars and airplanes. No doubt, cars and planes are better than they were in 1970. They last longer, are safer, more efficient, and cleaner, but they do the same thing today as they did in 1970–move people across countryside at average rates of speed that haven't changed substantially since.

The Army Research Laboratory predicts a revolutionary future for the Army of 2030 from developments in the physical, life, information, and engineering sciences.[4] This could come from technological improvements such as lighter materials, the continued improvement of command and control, precision fires, autonomous and semi-autonomous systems, and new vertical takeoff and landing capabilities. But while new technologies may be developed, overmatch will be ever harder to sustain with these kinds of incremental improvements being quickly matched through proliferation or hybrid warfare.[5]

Maj. Mark Van Horn, U.S. Army, is an intelligence officer currently assigned as the battalion operations officer in the 522nd Military Intelligence Battalion, 207th Military Intelligence Brigade. He worked as a theater war games planner for U.S. Army Europe from 2014-15 and was at the Mission Command Training Program from 2011-12, where he observed over a dozen brigade staffs conduct war games. He is a graduate of the Command and General Staff College, the University of Southern California, and Norwich University.

Advanced weapons technologies will spread—future threats will have access to the same technologies we do and at a decreasing cost. Or, at the very least, they will have technologies threatening enough as to render the capability gap operationally and tactically surmountable due to the inherent snags of complex terrain. Combined arms maneuver tactics and operational art have changed little since World War II, and fieldings of any new technology in the next twenty years stand to not change them that much either.[6] Many U.S. weapon systems, even though developed thirty to fifty years ago, are still some of the best in the world but other world powers will soon catch up and for the next twenty years, the U.S. Army will be operating with systems developed in the 1970s and fielded in the 1980s; further advancements will be improvements to original designs.[7]

So senior leaders should be skeptical of industry claims to produce any kind of "revolutionary" weapon systems. Enemies adapt quickly and often cheaply.[8] The development of advanced weapon systems are a high risk investment for what may be minimal returns (as in the revolution that occurred when manual can openers became "automatic").

While impending enemies will inevitably avoid or negate U.S. technological superiority, it doesn't matter your technological advance or the systems you hold, you must compete against the ultimate weapon—other minds. Future innovations must focus on the social and human dimension of war.[9]

For the discipline and exercise of the warrior's mind, war games are an inexhaustible arsenal, and the best sparring arena ever developed for it.[10] War games are like chess and fingerprints, they are practically infinite in possibility and uniqueness. Their application to soldiers' cognitive, and social training requirements nests perfectly with the U.S. Army's Human Dimension Concept. War games can provide data about ourselves and inform human resource management. They are a powerful cognitive aid, a thing to help us think, and an aid for probing the future, as well as how soldiers decide.[11]

Ultimately, war games are the only venue which affords the military the opportunity to wage wars and campaigns without taking lives. They are the closest thing we can get to a reconnaissance patrol of the future.[12] While there are many things of which we haven't an idea and have no idea that we haven't got one, just

because the future is uncertain and unknowable does not mean that it is a complete wash—impenetrable to wisdom and experiment.[13]

As an example: in 1994, the Office of the Secretary of Defense commissioned the RAND Corporation to perform a series of futures war games. Their results were nearly identical to what passes today as the future of war twenty years later. The authors remarked how uncertain the security environment had become, and forecasted the rise of area denial systems, irregular warfare, regional threats, and the strategic overmatch that comes from opponents who are far more willing to use weapons of mass destruction. They did not predict 9/11 or Operation Iraqi Freedom or a Global War on Terrorism but in the broad outlines and trends of future nation state warfare their forecast was mostly right.[14] War games are vital as a tool for coping with uncertainty.

Yet, in spite of all their promise, in war gaming there are limits. They are not like physics experiments.[15] It is difficult to record what happens and to repeat and replicate. It is difficult to explore variations in the decisions made and their outcomes; it is infeasible to explore all the possible mistakes.[16] And good luck trying to imitate the ways Murphy so painfully complicates the actual strategy and execution of military operations. Many of the difficulties above stand to be mastered by coming inventions in big data. Collect large enough stacks of data and probabilistic correlations and forecasts can be sufficient to understand human behavior and thinking.[17] Inside war games, the Army can use big data collection methods to study the human side of warfare in revolutionary ways.

Big Data War Games Make Military Decision Making Quantifiable

While physical weapons technology stalls, big data innovation rockets upward at an exponential clip. "When it comes to generating economic growth, providing public services, or fighting wars, those who can harness big data effectively will enjoy a significant edge over others. In time, big data might change our way of thinking about the world," proclaim authors Cukier and Mayer-Schoenberger from their 2013 Foreign Affairs cover story. Data points, previously never even imagined as possible, like mouse clicks, the 207 pressure points on your backside as you sit in a vehicle, and the life on your smart phone, are being collected and stored and queried and analyzed by armies of statisticians and economists and social scientists.[18]

In Army operations, as well as in our command-post exercises, every war fighting function is represented by a corresponding digital information system that is a huge potential data source. War games are perhaps the only medium that the Army can use to capture the big data of the military decision-making process. Digitized war games, not just in exercises but for operations planning, can use already existing systems of record to collect data at a scale previously unimagined. This is the challenge of a military big data science: first deciding how to assign numbers to a qualitative process, then collecting large swaths of data, and then turning it into useful knowledge. Pulling the military decision-making process into the world of bytes is only realistically going to be done through big-data type war games. It would transform an ineffable and qualitative experience into one that can be measured and could correlate decisions with outcomes. Being able to digitize and collect a lot of information about how leaders are making decisions in war games will feed cognitive research into how we wage war.

The hope of the cognitive sciences and big data is that one day we may be able to use these kinds of large data sets to outwit the modern day maladaptations of our ape minds. Any army that could reduce cognitive biases in thinking would have an incredible advantage in war. There is a project from the Intelligence Advanced Research Projects Agency called Sirius to train intelligence analysts out of their cognitive biases using simulations and interactive games.[19] Results aren't out but games that could reveal an individual's own biases truly are a revolutionary technology for soldiers. Training organizations out of larger group based cognitive biases would be an even more significant innovation and could come from big data type war games.

The Future of War Games

Big data war gaming is a way the Army can grab hold of the big data revolution and apply it to the indeterminate art of war.

First, the Army will need to learn how to sieve petabytes worth of data and find those correlations most pertinent to military decision making. This is no small task. It requires the collection and storage of

the right data sets, then the tools and analysts to turn it into knowledge. We should not think this comparative to running a startup. Facebook and other social media sites are designed to capture metrics about qualitative decision making: likes, follows, retweets, exhaustive question and answer surveys for online dating, your music library, the spending of imaginary and real monies, and so forth. Our war fighting function information systems in contrast, do no such thing. There is no survey or background data taken when you start using Command Post of the Future or the Distributed Common Ground Station. Users are not tracked through either of these systems for the life of the user. Perhaps we should start. Big data war games offer the perfect opportunity to track how users use the Army's various information systems. Advantageously, this dovetails with other opportunities to figure out our approach to big data war games like correlating performance records with observations in war games.

Our evaluation system is being converted into digits. The ability to finally see correlations in performance reports from the time tens of thousands enter the service to when they exit and to do this longitudinally is both a start to figuring out data points for war games and the MDMP and a way to see if evaluations are capturing actions in the only environment that can approximate war. In data science, different fields, such as human resources in the case above, can offer surprising insights into areas previously thought unrelated so our gaze in developing big data wargames should be rather broad.

The Army should develop digitized board game- or computer game-like tools to help staffs from battalion to corps plan during the war gaming step of the orders process. My vision for this technology would be table top size, interactive electronic maps, like an iPad, that participants can use to create enemy and friendly orders of battle and to record moves and outcomes. These war gaming tools would connect to centralized databases so that war gaming inputs can be collected from across the Army.

Regardless, the future of victory is not about silver or titanium or nanotube bullets. Neither should war game innovation be bound to the timelines and budgets of R&D. The exploration of how we capture and store big data about our war games is surely something that the Army Research Laboratory can explore. One immediate and needed improvement is the development of a war game or exercise planners course that moves beyond the models and sims and instead provides an introduction to the broad discipline of war gaming.[20]

Regardless of the data or the correlations that we can collect and point to in the outcome of our war games, war games are stories, and big data can't compensate for poor or biased narratives that are designed to test processes instead of outcomes.

Characteristic of the plot is that friendly forces have a three-to-one advantage and we are either attacking or performing wide area security missions. In combined arms maneuver war games, the Army is given overmatch and the Air Force has air superiority, because of course the Air Force doesn't need the Army to acquire air dominion. And the truly damaging or catastrophic impacts of a contested electromagnetic spectrum or the loss of electric power could derail exercises so let's not do that either. The plot is fixed in that the opposition force can't derail the locomotion of a commander's training objectives; a self-compromising standard if expecting a tough fight.

For many war games, the story is simple: liberate a country in however long the exercise can afford to be (usually about a week). This worked for the Gulf War but we should not expect this in our future wars. When facing a hybrid threat in particular, campaigns can go on for years so you need small scenarios with matching objectives. You aren't going to defeat a hybrid threat in a week. Even if the training objective is to fight force-on-force, it's dangerous to think it will always be guaranteed quick and easy.

Such storylines fail to prepare soldiers and leaders for the winning part of "Win in a complex world," because the training audience knows they can't lose. If you want to practice the "win" then you have to be willing to experience the loss. Otherwise, all your training is just in processes, instead of correct thinking.

One war game story the Army needs to play at is a retrograde scenario. The greatest weakness we have is projecting land power. While we wait to build up forces we are vulnerable and it is not unrealistic to think we'll be challenged when we are weakest. This scenario is important to war game because it can reveal things we haven't any idea or experience about yet. Institutionally, we don't think we'll lose because we're so much better than everyone else's army. If anything, playing a retrograde scenario prevents professional hubris and gives

the Army an experience we need, albeit one we never want. I think it is also something we should do to build resiliency, when you are facing hard odds, it helps that you've worked through it conceptually.

These are a few suggestions, my own recommended probes for the future of war gaming. The broader point is that beyond the technological possibilities of big data and war gaming there are needed innovations, which are cheap and can have an immediate impact, to be made in the stories we play right now.

The End Game

Narrowing technological gaps, the phenomenal rate at which knowledge is disseminated, a contested electromagnetic spectrum, and the speed at which events occur means the returns on trying to develop next generation physical weapons technology are inevitably bound to dwindle. The future of war is to leverage our industrial and research base to support one of the instruments warriors play for learning how to win in a complex world. ■

Notes

1. "A war game is a simulation involving two or more opposing forces using rules, data, and procedures designed to depict an actual or assumed real-life situation." Joint Publication (JP) 1-02, *Dictionary of Military and Associated Terms* (Washington, DC: U.S. Government Printing Office [GPO], 2015).

2. Edward O. Wilson, *The Meaning of Human Existence* (Liveright Publishing, 2015), 56-57; Martin Ford, *Rise of the Robots* (Basic Books, 2015), 64-67.

3. For an overview of rising defense R&D costs see: James Fallows, "The Tragedy of the American Military," *The Atlantic* (Jan/Feb 2015), http://www.theatlantic.com/features/archive/2014/12/the-tragedy-of-the-american-military/383516/. Fallows blames exponential costs on politics and corruption but does not consider that it is just more expensive to develop technologies that are ever more complex.

4. Army Research Laboratory, *Army Research Laboratory Technical Strategy 2015-2035* (U.S. Army RDECOM, 2015).

5. Training and Doctrine Command (TRADOC) Pamphlet 525-3-1, *The U.S. Army Operating Concept: Win in a Complex World* (Fort Eustis, VA: TRADOC, 31 October 2014); Army Capabilities Integration Center, Future Warfare Division, "Strategic Trends Analysis: The Landscape of Future Conflict," *Unified Quest Deep Future Wargame 2030-2040* (Fort Eustis, VA: Army Capabilities Integration Center, 20 November 2013).

6. Stephen D. Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton University Press, 2004).

7. Michael Howard and John F. Jr. Guilmartin, *Two Historians in Technology and War Monograph* (Carlisle Barracks, PA: Strategic Studies Institute, U.S. Army War College, 1994), 21-22; Robert D. Jr. Hooker, *American Landpower and the Two-War Construct* (The Institute of Land Warfare, Association of the United States Army, 2015).

8. Insights from an industrial design class at MIT see: Lt. Gen. H. R. McMaster, "Superiority by Arthur C Clarke," Professional Reading Series 18 (Fort Eustis, VA: Army Capabilities Integration Center, 3 December 2014), http://www.arcic.army.mil/LPD/professional-readings-archive.aspx?pageNo=6.

9. United States Army Combined Arms Center, *The Human Dimension White Paper: A Framework for Optimizing Human Performance* (Fort Leavenworth, KS, 9 October 2014).

10. Peter P. Perla, *The Art of Wargaming* (United States Naval Institute, 1990).

11. The technical concept and term is "cognitive artifact;" see, The MIT Encyclopedia of the Cognitive Sciences, accessed 2 July 2015, http://ai.ato.ms/MITECS/Entry/hutchins.

12. "If done carelessly, war games can seem to the players to produce insights or conclusions that have a basis no more solid than that of a debate or play" from Kenneth Watman, "War Gaming and it's Role in Examining the Future." *Brown Journal of World Affairs* 10, no. 1 (2003): 51-61.

13. Martin Krieger, "Uncertainty Principles," *Academic Minute* (March 2015), http://academicminute.org/2015/03/martin-krieger-usc-uncertainty-principles/v.

14. Bruce W. Bennet, Samuel Gardiner, Daniel B. Fox, and Nicholas Witney, *Theater Analysis and Modeling in an Era of Uncertainty: The Present and Future of Warfare* (Santa Monica, CA: RAND Corporation, 1994).

15. For an example of war gaming as experiment see Ryan Kort, "UNIFIED CHALLENGE 2014 Experimentation: Thinking Clearly About the Future of Armed Conflict" (Fort Eustis, VA: Army Capabilities Integration Center 24 March 2015), http://www.arcic.army.mil/Articles/cdld-Unified-Challenge-2014-Experimentation-Thinking-Clearly-About-the-Future-of-Armed-Conflict.aspx.

16. Peter P. Perla and Ed McGrady, "Why Wargaming Works," *Naval War College Review* 64, no. 3 (Summer 2011).

17. Christian Rudder, *Dataclysm: Who We Are (When We Think No One's Looking)* (New York: Crown Publishers, 2015), Kindle edition, loc. 128-146.

18. Kenneth Cukier, and Viktor Mayer-Schoenberger, "The Rise of Big Data: How It's Changing the Way We Think About the World," *Foreign Affairs* 92, no. 3 (2013).

19. IARPA. Sirius, accessed July 3, 2015, http://www.iarpa.gov/index.php/research-programs/sirius.

20. I could find no Army Training Requirements and Resources System course for either an exercise planner or war game planner.

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