ARTIFICIAL INTELLIGENCE: THE MEANS TO DEFEAT LOW YIELD BATTLEFIELD NUCLEAR WEAPONS

A Monograph

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Abstract

Artificial Intelligence: The Means To Defeat Low Yield Battlefield Nuclear Weapons, by MAJ Justin A. Ruholl, 55 pages.

Near peer adversaries such as Russia and China understand that they cannot compete and win a traditional conflict with the United States (US). For Russia and China to be victorious against the US, they developed new means and capabilities through technological advancements to be victorious on the battlefield. One of the primary capabilities under development is low yield battlefield nuclear weapons (LYBNWs) to win against the United States in future conflicts. The American near-peer adversaries will launch an LYBNW on American maneuver forces to eliminate them from the battlefield and not elevate the conflict to the all-out nuclear war threshold.

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Abbreviations

AAADS	Autonomous Artificial Intelligence Air Defense System
AI	Artificial Intelligence
AIAMD	Army Integrated Air and Missile Defense
BN	Battalion
DOD	Department of Defense
IAMD	Integrated Air and Missile Defense
IBCS	Integrated Battle Command Post
ICBM	Intercontinental Ballistic Missile
JIAMD	Joint Integrated Air and Missile Defense
km	kilometers
LYBNWs	Low Yield Battlefield Nuclear Weapons
MCTS	Monte Carlo Tree Search
MSE	Missile Segment Enhancement
PAC	Patriot Advance Capabilities
TBM	Tactical Ballistic Missile
THAAD	Terminal High Altitude Defense
US	United States
WWI	World War I
WWII	World War II

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Introduction

Since the beginning of any war, man has utilized advancement in weapons technology to increase his chances of victory during conflicts. The evolution of new weapon systems was vital throughout disputes in history. The leader or nation that can implement the new technology with current systems or platforms is victorious. A prime example in history is the development of rifles and cannons implementation on the battlefield. In 1805 and 1806, Napoleon utilized these two technological advancements in combination with the cavalry to win critical victories, and one example is the Austerlitz campaign. Nations across the world saw the rifle and cannon mixed with maneuvers as a breakthrough in war. In the following years, countries in Europe and worldwide were in an all-out race to build and train their military might in the same way Napoleon had done before the Jena campaign and other conflicts. The evolution of weapon technological continues to increase as time passes. The next weapon system that changed the execution of future wars was airpower.

The first airplane flew in 1902 and its minor advances limited air power to reconnaissance capability and constrained air fighting in World War I (WWI). Leaders of the time envisioned airplanes as the future means to fight conflict through airpower. The advancements of airpower came to fruition in 1945 during World War II (WWII). Airpower, coupled with land forces, allowed the American strategic advantage over Germany. The United States understood the capabilities that airpower brought to the battlefield to attack enemy targets along their lines of communication and the main front. Airpower allowed ground forces to maneuver on the battlefield engaging the enemy on an all-out front to attrite the German army and win the war. Another example of airpower contributing to in victory of WWII was in the Pacific campaign against Japan. Airpower was able to bomb enemy targets during the island-hopping missions as well as attack mainland Japan. Ultimately airpower delivered the atomic bomb to force the Japanese to surrender in WWII.

History provides an accurate picture of nations who wield technological advancements to be victorious in war or deter a conflict. Former Defense Secretary Mark Esper understood the importance of technological advancement when he stated, "History informs us that those who are first to harness once-in-a-generation technologies often have a decisive advantage on the battlefield for years to come."[1] What will be the next technology that will change how wars are fought and won? Adversaries such as Russia and China see the next technological advancement that defeats America to be low yield battlefield nuclear weapons (LYBNWs).[2] Russia and China envision a scenario where American ground forces are maneuvering on the battlefield with limited air defense protection and terrain channeling them into a massive kill box. Russia or China will then use LYBNWs with a mixture of tactical ballistic missiles (TBMs) to target American ground forces and key areas such as wet gap crossings, support areas and logistical lines.[3]

Leaders in the American military have focused on a broad range of technological advancements from long-range fires, tactical nuclear, hypersonic missiles, drone swarm, and space capabilities. With so many new technologies crowding the battlespace one capability that has attracted the interest of the military and civilian sectors is artificial intelligence (AI). In the Army, AI is an underdeveloped weapon system that can be the next technological advancement in war. AI will give the US Army the means and advantage on the battlefield, just like the cannon

[1] Jim Garamon, "Esper Says Artificial Intelligence Will Change the Battlefield," *DOD News*, September 9, 2020, accessed November 25, 2020, https://www.defense.gov/Explore/News/Article/Article/2340972/esper-says-artificial-intelligence-will-change-the-battlefield/.

[2] Dr. Lester W. Grau and Charles K. Bartles, *The Russian Way of War: Force Structure, Tactics, and Modernization of the Russian Ground Forces* (Fort Leavenworth, KS: Foreign Military Studies Office, 2016), 205-206.

[3] Office of Secretary of Defense, *Military and Security Developments Involving he People's Republic of China* (Washington, DC: Government Publishing Office, 2020), 88, accessed May 4, 2021. https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/1/2020-DOD-CHINA-MILITARY-POWER-REPORT-FINAL.PDF.

and airpower. Additionally, AI will assist the US Army in detecting, classification, and nullifying LYBNWs in a large-scale fight.

Problem Statement

Near-peer advisories to the US are continually trying to develop the next weapon system to give them the advantage on the battlefield to win in war. Russia is developing hypersonic weapons; meanwhile, China exploits long-range precision fires to keep their enemy at a distance. However, both threats are centering efforts on LYBNW to destroy the American maneuver force in a future conflict.[4] Currently, the American air defense platforms lack the technology and capacity to combat the emerging threat of LYBNWs mixed with TBMs in a large-scale conflict.

Purpose of the Study

This monograph intends to provide options for integrating AI into Army air defense systems to defeat LYBNWs. First, the monograph will look through the lens of history to show how significant it is to develop technological advancements and integrate them into existing systems to be victorious on the battlefield or in war. The primary weapon systems used for the research study are the cannon, airpower, and nuclear weapons. The historical analysis allows readers to foresee that America must continue to develop technological advancements, particularly in AI, to have a positive impact on future conflicts. Second, the monograph focuses on current and future air defense platforms the US Army currently has for war. This portion of the investigation educates the readers on the systems' capabilities and limitations to understand the air defense operating environment and shortfalls leading to a need for an integrated AI. Third, the monograph focuses on AI capabilities in algorithms and platforms currently in the civilian and military sectors. The algorithms provide insight into machine learning capabilities for proposals

[4] Hans M. Kristensen and Matt Korda, "Tactical Nuclear Weapon, 2019," *Bulletin of the Atomic Scientists* 75, no. 5 (2019): 3.

on an AI platform in conjunction with current systems. Finally, the paper concentrates on the recommendation of integration and the need for an autonomous AI system to defeat LYBNWs.

Significance of the Study

This study matters to the US Army because near-peer advisories develop new and enhanced missile platforms to win future conflicts, especially LYBNWs. The emergence of these weapon systems is slowly outmatching the US Army's current air defense systems. This study provides a course of action to regain the advantage by combining AI with current platforms to provide enhanced air defense coverage. Meanwhile, allowing time for an autonomous weapon systems to be built. Utilizing AI capabilities in an integrated air missile defense (IAMD) provides early warning, speed in engagements, distance in targeting the threat, and, more importantly, deterrence. Air defense systems are a deterrence to world powers once deployed to an area of operation. The augmentation of AI enhances American capabilities deter or defeat aggression, and preserve land forces.

Literature Review

Artificial Intelligence

Currently, there is no unclassified literature on AI imbedded in American IAMD systems. This paper is a step toward shedding light on the topic and generating options to capitalize on AI.

Basics of AI

According to the Cambridge Dictionary, artificial intelligence is "the study of how to produce machines that have some of the qualities that the human mind has, such as the ability to understand language, recognize pictures, solve problems, and learn."[5] An excellent example of this process would be a robotic AI looking at a basketball and adequately identifying it as a ball

[5] Cambridge Dictionary, "Artificial Intelligence," accessed February 11, 2021, https://dictionary.cambridge.org/dictionary/english/artificial -intelligence.

within its programming. The computer will then verbally describe the basketball's shape on the table across multiple languages and decide on how to utilize the object. However, to have a proper understanding of AI, you must first reference the system's beginnings.

The first conception of AI emerged in 1943 by Warren McCulloch and Walter Pitts in the neurons' framework.[6] The developers wanted a computer to conduct the same actions as the human brain using algorithms and probabilities. The theory came from analyzing the human brain and how the neurons functioned. Their study executes a series of tests on artificial neurons' response to negative and positive stimulation. The study results showed that the neurons could learn from each other's response to the stimulus.[7] More importantly, a machine could compute through a network of connected neurons and a computer network structure.[8] It allowed the computer to learn from data that was available, just like the human brain. This study of neural networks was the start of the AI process and its development from 1943 to 1956.

The next research study on AI occurred at Dartmouth College, led by John McCarthy.[9] The goals that he set for his team were to research automata theory, neural nets, and the study of intelligence.[10] The study was over a ten-month period where the team attempted to have a machine execute problem-solving, use a language, and learn from its actions. The research had high aspirations but would not succeed in developing a machine learning AI. However, the study did succeed in the creation of neural networks. The next step in the evolution of AI will come in the form of algorithms.

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[6] Stuart J. Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed. (Upper Saddle River, NJ: Pearson Education, 2020), 17.

[7] Ibid., 18.

[8] Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, 2nd ed. (Sebastopol: O'Reilly Media, 2019), 280.

[9] Russell and Norvig, *Artificial Intelligence*, 18.

[10] Ibid., 19.

Algorithms

An algorithm is a step-by-step directive that informs the machine it must execute certain functions to achieve the end state. Programmers that write the main algorithm's goal are to create rules that allow the AI to perform its duties timely and without flaw. The first algorithm, called the nearest neighbor, was developed in 1967 by Marcello Pelillo.[11] This algorithm focused on mapping for a salesman who traveled from city to city. The system ensured that the salesman stopped at the correct locations in the most efficient manner.[12] The nearest neighbor program showed that a machine through neural networks could solve problems promptly. This simple system elevated AI to a new level. However, over the next 33 years, AI advances faced ups and downs until 2001 with the concept of big data.

Big Data/Deep Learning

Big data structures are an extensive set of information instantaneously. The information sets have trillions of images, videos, words, speech, vehicle tracking clickstream, or social network data. The main factor that assisted in developing big data was the internet. Before 2001 computers were large and standalone. The creation of the internet allowed computers to become connected and share data. Even though the internet was in an early phase in 2001, it still had 10,000 websites compared to the over 30 billion today.[13] Combining the data from computers with the internet allowed a breakthrough in algorithms. Developers could create algorithms that could sort through a mass amount of data to provide solutions to problems, producing a new learning algorithm framework. The learning algorithms eventually helped develop deep learning computers in 2011. Machine learning came about by expanding on the neural networks' concept

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[11] Keith D. Foote, "A Brief History of Machine Learning," *Dataversity*, March 26, 2019, accessed September 18, 2020, https://www.dataversity.net/a-brief-history-of-machine-learning/.

[12] Benard Marr, "A Short History of Machine Learning--Every Manager Should Read," *Forbes*, February 19, 2016, accessed September 18, 2020, https://www.forbes.com/sites/bernardmarr/2016 /02/19/a-short-history-of-machine-learning-every-manager-should-read/#7cf2ee8f15e7.

[13] Dee Kris, "What Was Technology 20 Years Ago?," *Tech News Gadget*, March 26, 2018, accessed September 20, 2020, https://technewsgadget.net/2018/03/what-was-technol ogy-20-years-ago/.

to store and analyze data. The success of deep learning systems opened new opportunities for machine learning in the AI domain.

Machine Learning

Machine learning is the concept of AI automatically learning from accessible data and experience without being programmed numerous times. Once again, this is possible because of access to big data. The computer can view data at a high rate of speed and make a choice internally. Once that choice is decided, the program in the computer stores the results. Machine learning will repeatedly occur until the computer has options with mathematical variables. The computer will choose the option with the high numerical marker as the best decision.[14] Many programs currently use machine learning, such as Monte Carlo Tree Search (MCTS), found in the gaming industry.

The MCTS is a machine learning program that operates under a search algorithm for a decision process. One way to analyze this decision process is to apply it to the game of chess. The algorithm's first step is selecting what move it must initiate to ensure it wins the game. Once the program has identified the move, it will layout nodes in a tree pattern from top to bottom with a mathematical value. The program then will pick the best moves utilizing the nodes. The next step in the process is the expansion and simulation of multiple tree nodes. The expansion allows the algorithm to set up numerous branch plans to run various simulations to find the best way to win the game (see figure 1). The program then executes the back-propagation parameter updating all the tree nodes and stores for future play. Not once does a programmer or developer write a new algorithm because the machine is learning on its own. Overall, machine learning is a valuable tool to be utilized, but it has challenges.

[14] Russell and Norvig, *Artificial Intelligence*, 148.

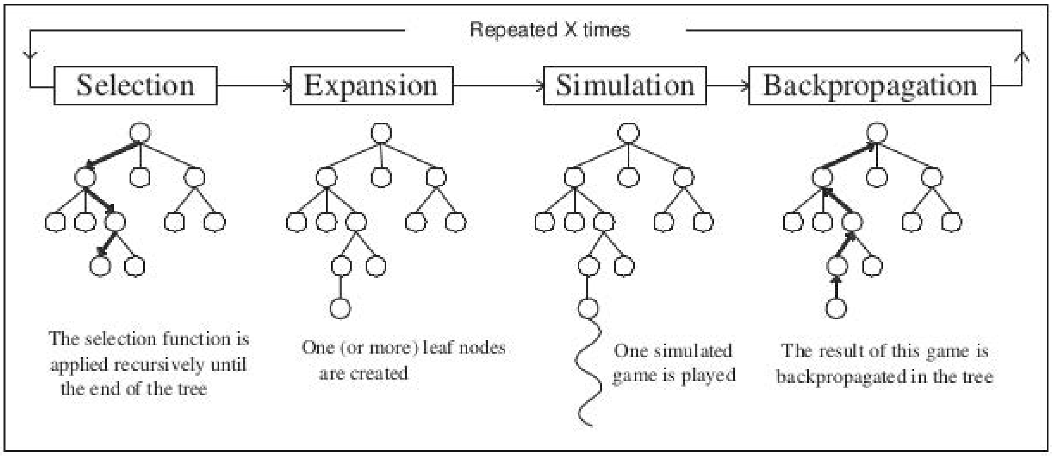

Figure 1. Monte Carlo Tree Search. Stuart J. Russel and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed. (Upper Saddle River, NJ: Pearson Education, 2020), 162.

Challenges

Technology and Computers

In the last 70 years, technology has hindered AI from reaching its full potential. In the early years of AI, the software was not technologically advanced to handle the massive data required for machine learning.[15] The circuit cards at the time only had a certain amount of storage for data. Not to mention the circuit cards themselves were large and bulky. For AI to emerge as a new technology during its early years, a computer required a massive amount of circuit cards, which meant a large amount of space to store the system (figure 2). Furthermore, the elements needed to build the circuit cards cost substantially, and their production was at near nonexistent levels. Research and developers in the early years of computers did not have the monetary means or space to exploit AI's true potential or possibilities. However, that would change years later by developing a network of interconnected information flow termed the internet.

[15] Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford: Oxford University Press, 2017), 10.

Figure 2. First Univac 1. Computer History Museum, “First Univac 1 Delivered to US Census Bureau,” Timeline of Computer History, accessed February 9, 2021, https://www.computerhistory.org/timeline/computers/.

The first version of the internet was created in 1960 by the US Department of Defense (DOD) called the advanced research projects agency network (ARPANET). DOD wanted a communication network between computers. The transfer of communication did occur in 1969 between a computer at UCLA and Stanford.[16] However, only a small message transmitted, and less than an optimal amount of data was transferred, which did not help develop AI machine learning. The internet did increase its data storage and transfer capability in 1983 with the creation of the world wide web, but it still was not enough to have emergent AI technology. Fast

[16] Giovanni Navarria, “How the Internet was Born: From the ARPANET to the Internet,” The Conversation, November 2, 2016, accessed December 14, 2020, https://theconversation.com/how-the-internet-was-born-from-the-arpanet-to-the-internet-68072.

forward to 2021, and the internet can now provide the required amount of data to assist in a promising AI technology advancement. Furthermore, the internet allows an AI instantaneous access to data worldwide, unlike before, where a human developer had to input the data. Even though technological advancements occurred, many scientists believe it will be at least another 50 years before creating a fully complete self-learning AI.[17]

Methodology

Grounded Theory

The method for this research was grounded theory. Anselm Strauss and Barney Glaser developed grounded theory in 1967.[18] Overall, grounded theory is a qualitative method that provides a flexible option for researchers who need to analyze various data types. The grounded theory concept allows researchers to gather mass amounts of data, categorize the data, and write memos to capture essential information. Grounded theory expands research further by allowing theoretical sampling, comparative analysis, theoretical sensitivity, intermediate coding, identify a core category, and develop advanced coding in a generated theory. Reference the grounded theory framework in figure 3 to visualize the full process.[19]

The first step within grounded theory focuses on gathering and coding data.[20] The researcher identifies essential words in the title and reading to be categorized. The categories description must describe the information in a broad term and coded appropriately. The next step in grounded theory is data generation and analysis of what is collected.[21] During this process, the

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[17] Mike McRae, "Experts Think This Is How Long We Have Before AI Takes All of Our Jobs," *Science Alert*, June 6, 2017, accessed September 23, 2020, https://www.sciencealert.com/experts-think-this-is-how-long-we-have-before-ai-takes-all-of-our-jobs.

[18] Melanie Birks and Jane Mills, *Grounded Theory: A Practical Guide* (London: Sage, 2015), 2.

[19] Ibid., 13.

[20] Ibid., 90.

[21] Ibid., 71.

researcher only collects data, unlike other theories, where the hypothesis is in the first step. Following the collection of data is writing memos on the coded information.[22] The memos allow the researcher to reference information, but more importantly, it leads them to develop a theory at the end of the process. The next step in the process is theoretical sampling by the researcher. Sampling occurs when the researchers identify potential links between the coded information and decides what sources or areas to expand their research.[23] During the sampling process, the researcher is congruently comparing and analyzing the data. The researcher starts to see patterns or links to help them theoretical sample by comparing and analyzing. Researchers begin to formulate their theory from the coded data at an early stage during the theoretical sampling step. This stage is not complete until the final stage of advanced coding. For the development of theory to continue, the researcher must conduct intermediate coding.[24] During the intermediate coding step, the researcher is fine-tuning his or her group of data to identify the core category that develops their potential theory. The researcher's theory comes to fruition with the final step of advanced coding. During the development of advanced coding, the researcher looks at the coding and data and develops a storyline.[25] The storyline lays out a road map of data from start to finish that supports the generated theory's final development.

[22] Birks and Mills, *Grounded Theory*, 75.

[23] Ibid., 119.

[24] Ibid., 95.

[25] Ibid., 113.

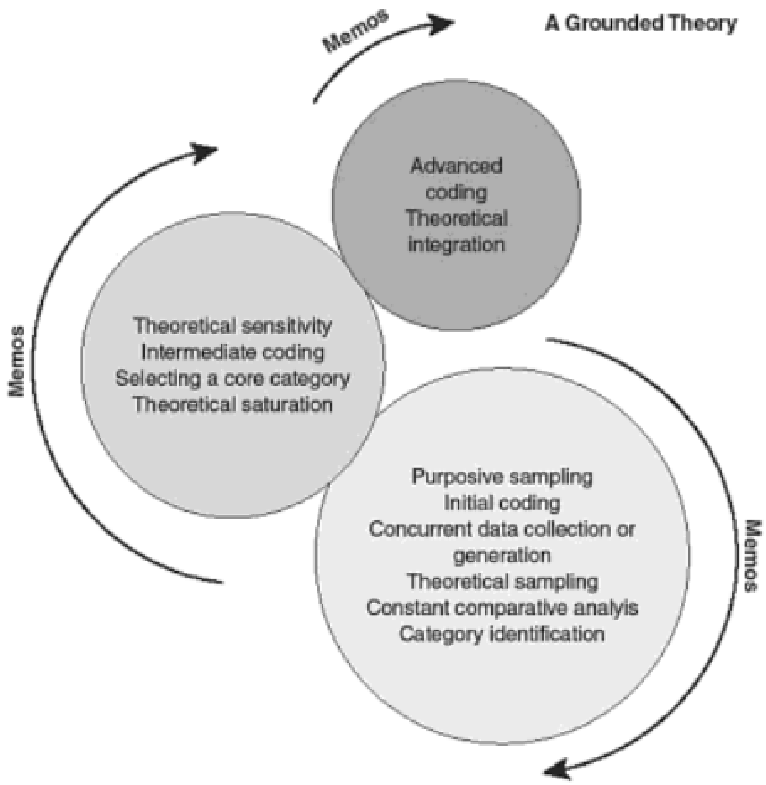

Figure 3. Grounded Theory. Melanie Birks and Jane Mills, *Grounded Theory: A Practical Guide* (London: Sage, 2015), 13.

This paper's initial coding started in five categories, history of technological advancements, AI, air defense artillery systems, human dimension on AI, and future technology. Within the categories, a pattern started to emerge in technological advances to be victorious in conflict and humans deciding to implement the new system. All five of the categories and patterns can be found in learning from the past and adapting to the present sections of this paper.

Noticing the patterns of technology brought the study to the intermediate coding and identification of three new core categories starting with AI, which had two subcategories under military and civilian domains that explored potential emergent technology. The second category will be near-peer weapon advancements specifically focused on LYBNWs and how the enemy will utilize this type of threat. The third category is air defense, emphasizing current and future platforms to see if the American military has the means to combat the LYBNWs threat. During this point of the study, the early development of AI as the means to defeat LYBNWs theory materialized. All three of the categories are found in the anticipating the future of air defense platforms and AI sections of this paper.

For the theory to come to fruition, the study had to move to the final step of advanced coding, which developed three categories. The first category is AI integration into air defense, which showed robust platforms to implement the system as a current supplementation to combat LYBNWs. The second category is autonomous AI requirements, which provided the conditions for such a system to be developed and implemented. The advanced coding step's final category is the autonomous AI air defense system, which offers options to defeat LYBNWs proficiently. The recommendation for artificial intelligence section provides the insight to the three final categories. Overall, bringing the study to the conclusion that AI is the means to defeat LYBNWs.

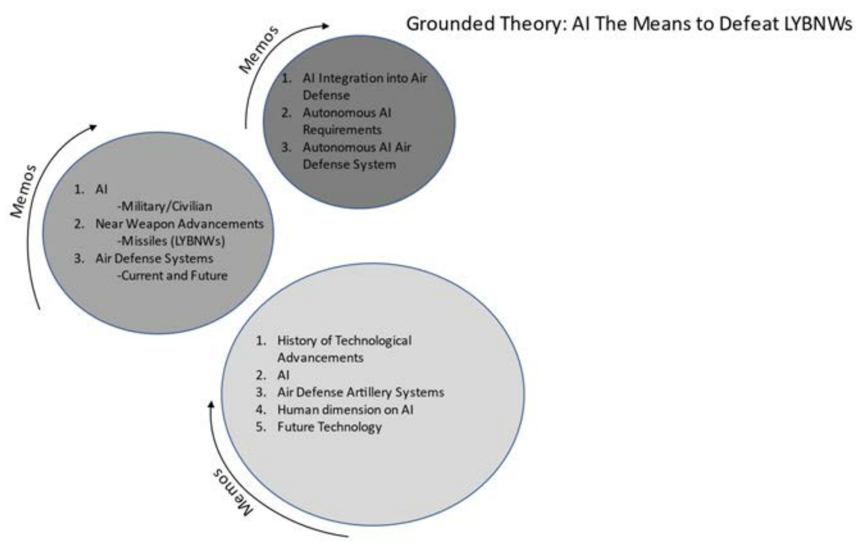

Figure 4. Ground Theory: AI the Means to Defeat LYBNWs. Created by author.

Learning from the Past (Initial Coding and Categorization)

The first theme within my grounded theory methodology was focused on history. Throughout history, nations saw technological advances in weaponry that changed the course of a battle or war. One weapon was the cannon. The first primitive cannon emerged in 1250, named the Arabian *Madfaa*.[26] The cannon's essential components were wood frames, a metal gun tube, and the use of an explosive charge to fire a projectile towards the enemy. Countries would try to expand on this new weapon technology by having variances of projectiles in the form of stones or spikes. One of the most dramatic improvements was in 1453, leading up to the battle of Constantinople.[27] Urban developed the cannon named Dardanelles that weighed 37,000 lbs. and fired a projectile weighing 1,600 lbs.[28] This massive cannon mixed with other small artillery had a devastating effect on the people and soldiers during the siege, overwhelming their ability to respond, and resulting in victory. Even though the Dardanelles was a fantastic accomplishment for the cannon's ere, many horses and personnel still required transport. A critical evolution of the cannon would be in the 15th century in three forms. The first would be cannons' cast to make them lighter, and the second form would be the addition of the carriage to provide increased mobility, and finally, the cannon shot balls versus lobed projectiles. The new additions allowed commanders of the battlefield to move cannons creating an offensive option rather than the simple and static use in a defense position.

Primarily, the cannon brought an explosive impact to the battlefield for nations going to war on the tactical and operational levels. Tactically, the cannon could engage enemy infantry, and cavalry. Cannons created reach and reduced time and space enabling engagements at a further distance than the bows and muskets of the era. The cannon would be able to wreak havoc

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[26] Bernard Brodie and Fawn M. Brodie, *From Crossbows to H-Bombs: The Evolution of the Weapons and Tactics of Warfare* (Bloomington, IN: Indiana Press University, 1973), 44.

[27] Ibid., 46.

[28] Ibid., 47.

on approaching enemy ranks, reduce their numbers, and devastate their morale. More importantly, the cannon could turn the tide of a battle by pinning down enemy formations to allow reserve forces to maneuver into position. On the operational level, the cannon changed the nature and conduct sieges compared to previous siege engines such as the catapult. In the past, armies had to surround the city, construct the catapults, lay siege, and storm the ramparts. Now, the increased power and range of cannon forced cities or fortresses to capitulate more expediently, and eventually led to changes and advances in fortress construction and engineering.[29] The cannon allowed the commander and his army to move onto the next objective leading to the overall campaign's success. One leader, in particular, Emperor Napoleon Bonaparte of France, used the cannon's benefits and mixed it with the musket and cavalry to win critical campaigns.

During the Austerlitz campaign, Emperor Bonaparte employed his troops in such a manner that allowed the cannon, artillery, and cavalry to mass troops and fires to gain victory. Napoleon's right flank was weak, making it a target for the Allied Forces (Russia and Austria).[30] The Allied Forces pushed to break Napoleon's right flank and then attack the center of his army.[31] However, due to arriving forces, cannon fire, and Napoleon's methodical planning, the right flank held off the attacking Allied Forces. The Allied Forces' advancement allowed Napoleon to advance in the center to cut the enemy battle lines.[32] During this time in the battle, Napoleon used his formations carrying muskets to maneuver, mass fires with cannons, and a key cavalry charge by his elite guard to break the center's enemy line resulting in a successful

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[29] Marija Obradovic and Slobodan Mišić, "Are Vauban's Geometrical Principles Applied in the Petrovaradin Fortress?" *Nexus Network Journal* 16 (2014): 751-766, accessed May 4, 2021, https://link.springer.com/article/10.1007/s00004-014-0205-9.

[30] Michael V. Leggierre, ed., *Napoleon and the Operational Art of War: Essays in Honor of Donald D. Howard* (Boston: Brill, 2016), 166.

[31] Ibid., 168.

[32] Ibid., 169.

campaign. Austerlitz's victory could not have come to fruition if the cannon advancement were not invited and employed. Most of all, success would not have occurred if Napoleon had not trained his soldiers on the weapons and integrated them into other existing war methods.[33] The next significant technological advancement for warfare occurred in the early 19th century and came from the sky.

The first airplane in flight was in 1903 by the Wright brothers in North Carolina.[34] The flight only lasted for 38 minutes. Even though the flight was short, the airplane started its journey towards the new technological weapon advancement. The first-time states implemented the aircraft was in the Italian Tripoli campaign in 1911. The airplane's primary function was to gather intelligence on enemy ground movement. However, during the Tripoli campaign, the pilots dropped bombs on targets that resulted in airpower development. In WWI, the Germans capitalized on airpower's concept in 1918 by fitting the airplane with armor, guns, bombs, and mass targeting critical threats. Airpower went through a second evolution in the interwar period between WWI and WWII. The airplanes were crafted to be faster, fly further distances, and carry a range of arsenal to increase their combat capability. As a technology air power promised to provide and time space advantage similar to the cannon. This was proved in WWII where German leadership utilized airpower in its Blitzkrieg plans and the bombing initiative against Great Britain. However, the most successful combined land and air campaign occurred in 1944 in Operation Overlord.

Operation Overlord was an invasion by Allied Forces (American, British, and Canadian) on five critical beaches in Normandy, France. Allied Forces employed naval firepower (cannons) and infantry (rifles) with landing boats to storm the beaches and take critical positions from the

[33] Robert M. Epstein, "Patterns of Change," *Journal of Military History* 56, no. 3 (July 1992): 376.

[34] Brodie and Brodie, *From Crossbows to H-Bombs*, 176.

German Army.[35] History books tend to focus on the naval and ground fight during this massive operation. One factor that led to the landing's success was the airpower offensive that occurred during the mission. The Army Air Corps had three tasks during Operation Overlord; maintain air superiority from the German Luftwaffe, strike reserve units moving to the beaches, and support the beaches' invading force.[36] Airpower was delivered by destroying German Luftwaffe planes on the ground, airfields, and any that may have arrived at Normandy. More importantly, the Army Air Corps destroyed German reserve units moving to reinforce their battle positions.[37] Airpower was a new powerful weapon that abled a country the means to reach deep into enemy territory. However, the nuclear bomb dropped on Japan started a whole new technological advancement race.

In 1945, US President Harry S. Truman directed the use of the first nuclear bomb instead of a land invasion of Japan.[38] The dropping of the nuclear bomb ushered in a new race of technological advancements in global and regional strike capabilities with America, Russia, and China. The arms race would define the rest of the century and continue to evolve over three distinct periods. During the first period, the emerging nuclear powers developed initial capabilities, all of which relied on aerial delivery. Russia built its first atomic bomb in 1949 and combined it with the Tu-16 for a fast delivery method.[39] China followed Russia's lead and built its first nuclear capability in 1967 and used its H-6 to deliver.[40] However, Russia and China eventually concluded that their aircraft could not deliver a nuclear bomb into the American

[35] Major Michael P. Dahlstrom, "The Role of Airpower in the Overlord Invasion: An Effects-based Operation" (Research Paper, Air University, Maxwell AFB, AL, 2007), 5, accessed December 2, 2020, https://books.google.com/books?id=ve3kAAAAMAAJ&source=gbs_navlinks_s.

[36] Dahlstrom, "The Role of Airpower in the Overlord Invasion," 7.

[37] Ibid., 6.

[38] Brodie and Brodie, *From Crossbows to H-Bombs*, 256.

[39] Editors of Encyclopedia Britannica, "Tu-16," accessed February 9, 2021, https://www.britannica.com/technology/Tu-16.

[40] John Wilson Lewis and Xue Litai, *China Builds the Bomb* (Stanford, CA: Stanford University Press, 1988), 207.

homeland or strike ground forces without a high probability of interception by air defense platforms. This risk of failure when employing aircraft forced a second evolutionary period of nuclear weapons. Russia and China built missiles to gain the time space advantage planes could not provide in order to achieve a battlefield advantage and make deterrent threats more credible. The technological advancements in nuclear missiles lead to the third evolution in LYBNWs. Both countries Russia and China, developed LYBNWs to keep the war threshold low, destroy a large ground force, and increase their deterrent capability.[41] A good example would be the Chinese DF-26, a tactical ballistic missile with range and maneuverability to destroy a ground force with nuclear means.[42] The speed and destructive capacity of LYBNWs will not only be a deterrent, but devastating to large ground formations during a conflict.

Overall, the cannon, airpower, and nuclear weapons developments are just a few case studies that have shown how technology has been used to gain an advantage. The case studies show that research, development, training, and integration of a new weapon system can demonstrably result in victory. For America to counter the emergent LYBNW threat, it needs to start researching a technology capable of providing an advantage, specifically AI. However, before looking at AI to defeat LYBNWs, we must look at the current US air defense systems capability to understand its shortcomings and as a provision for a future possible integrated platform.

Adapting to the Present (Initial Coding and Categorization)

The second theme that was noticed during the grounded theory process was the lack of capabilities of current air defense systems to combat LYBNWs. The US Army air defense branch

[41] Grau and Bartles, *The Russian Way of War*, 205-206.

[42] Julia Materson and Shannon Bugos, “Pentagon Warns of Chinese Nuclear Development,” *Arms Control Today*, October 2020, accessed February 9, 2021, https://www.armscontrol.org/act/2020-10/news/pentagon-warns-chinese-nuclear-development.

has quite a few capabilities to counter aircraft, tactical ballistic missiles, and low yield nuclear threats. Its three main air defense platforms are the Avenger, Patriot, and Terminal High Altitude Defense (THAAD). Each of the air defense weapon systems brings a particular combat advantage to the battlefield. However, these air defense platforms have limitations and issues that could put the maneuver force at risk during operations.

The Avenger is a mounted turret that sits on the back of a high mobility multi-purpose wheeled vehicle and has a defensive configuration consisting of eight stinger missiles and a .50 caliber mounted machine gun (reference Appendix A). The Avenger is mobile and can be inserted into a maneuver element to fend off close air threats. This means that the Avenger is meant to counter is rotary-wing, fixed-wing, cruise missiles, and unmanned aircraft.[43] The system can identify air threats through its onboard sensors and the crew member's ability to identify targets while in the turret. The Avenger can engage threats up to 8 kilometers (km) during maneuver operations.[44] In the static defensive operations, range increases with the assistance of its radar, the Sentinel. The radar has a 360-degree search bubble that elevates 9,800 feet that can alert the Avenger crew and provide an additional 40 km engagement range if appropriately placed[45] (reference Appendix B). More importantly, the Sentinel radar offers an early warning for other air defense platforms linked with the system through specific networks such as the tactical link or Link 16.[46] The link's primary purpose is to integrate and pass data to air defense units and other sister services to assist in the fight.

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[43] US Department of the Army, Army Techniques Publication (ATP) 3-01.64, *Avenger Battalion and Battery Techniques* (Washington, DC: Government Publishing Office, 2016), 1-1.

[44] Ibid., 1-10.

[45] US Department of the Army, Army Techniques Publication (ATP) 3-01.48, *Sentinel Techniques* (Washington, DC: Government Publishing Office, 2016), 1-1.

[46] US Department of the Army, Army Techniques Publication (ATP) 3-01.85, *Patriot Battalion and Techniques* (Washington, DC: Government Publishing Office, 2019), B-10.

The Avenger is of limited use to counter an LYBNWs threats it is not designed to engage ballistic missiles. As stated earlier, Avenger's responsibility targets rotary-wings, fixed-wings, and cruise missiles threats. Though an Avenger crew could not detect or defeat a LYBNW with the current onboard monitoring systems or weapons, its Sentinel radar could provide early warning to the Patriot air defense platform for engagement.

The Patriot air defense platform has a battle command post, engagement control station, radar, electronic power plant, and a minimum of six launching stations with a variance of interceptors: patriot advance capabilities (PAC-2, PAC-3), and missile segment enhancement (MSE). The Patriot weapon system primarily focuses on TBMs but has the means to target manned or unmanned aircraft, air-to-surface missiles, large-caliber rockets, and cruise missiles up to 150 km.[47] The engagement range for the Patriot weapon system is 150 km. Its dedicated radar sits at a 90-degree angle and is only directional, not 360-degree like the Sentinel radar (reference Appendix C). This configuration requires the Patriot air defense system to employ at least two radar systems when maneuvering on the battlefield to maintain coverage of its assets. The radar system can track multiple targets while controlling missiles' variations to engage the ones that threaten the assets it is defending.[48]

One of those variants is the PAC-2 missile that uses proximity detonation to engage the threat with hundreds of ball bearings as it nears the target.[49] Even though the PAC-2 had success in Desert Storm for destroying eight scuds, it did not destroy the warhead or potential submunitions. This left the possibility of an existing missile threat and drove the development of new munitions for the Patriot weapon system. The first enhanced missile would be the PAC-3, a transition from proximity detonation to a hit-to-kill engagement. The PAC-3 strikes the threat

[47] US Army, ATP 3-01.85, *Patriot Battalion and Techniques*, 1-5.

[48] Ibid., 4-8.

[49] Ibid., 1-3.

head-on utilizing velocity and a small explosive to kill the enemy missiles and any potential submunitions.[50] The follow-on missile with similar engagement criteria as the PAC-3 was the MSE. The function of the MSE was not only to destroy faster-emerging threats but provide options for air defense coverage at higher altitudes of the endo-atmosphere.[51] More importantly, combining the new MSE with the older model of missiles allows Patriot to defend against a wide array of threats, including the emergent LYBNWs threat. The Patriot system must determine which interceptor would be optimal to destroy a threat before that threat reaches its target. Even though the Patriot air defense weapon system munitions provide options to counter the LYBNWs, mobility, scarcity, and battlefield coverage, remain a systems limitation.

The first limitation that the Patriot air defense system faces is mobility. The weapon system is mobile, but it can only target threats once emplaced and not on the move. In the future fight, the maneuver force will be bounding forward in an expedited manner capturing objectives. The air defense protection sustainment mission requires coverage from a second air defense system to allow the movement to occur. Any lap of that coverage enables the enemy to strike with LYBNWs. The second limitation the air defense community currently faces is the number of Patriot systems within the fleet. Now, there are only 10 Patriot battalions (BNs) stationed in America and one of those is for testing. The majority of those BNs are on a year on and off deployment cycle to overseas locations to deter other Middle East threats. During large-scale combat scenario, the air defense branch will not have enough BNs and systems to maintain the maneuver force's full air coverage.[52] The third limitation is the new emerging LYBNWs that can be lofted or maneuvered outside or under the Patriot radar search sector during transitions on the

[50] Ibid., 3-10.

[51] US Army, ATP 3-01.87, *Patriot Battery Techniques*, 2-19.

[52] Bradley Bowman, Andrew Gabel, and Mikhael Smits, "Iran Attack Highlights US Missile Defense Vulnerability," *Defense News*, January 13, 2020, accessed December 12, 2020, https://www.defensenews.com/opinion/commentary/2020/01/13/iran-attack-highlights-us-missile-defense-vulnerability/.

battlefield. The Patriot air defense system would find it challenging to combat one of the low yield nuclear weapons, let alone a mixture of them and TBMs. However, the air defense branch does have the THAAD air defense system that could assist in lofted threats.

The THAAD system has a configuration like the Patriot air defense system. The system has a THAAD fire control and communications, radar, electronic equipment unit, six launching stations with eight missiles, a battery support center, and a THAAD battery command post.[53] The THAAD weapon system provides the means to engage TBMs or intercontinental ballistic missile (ICBM) threats at endo-atmosphere and exo-atmosphere altitude. The radar has a search sector of 1,000 km, but just like the Patriot, it can increase its range through other sensors and communication networks such as Link-16 (reference Appendix D).[54] The THAAD missile is also a hit-to-kill missile using velocity and a small explosive to hit a threat, destroy the vehicle and any submunitions.[55]

The first limitation that the THAAD radar system faces is the lack of organic defense. THAAD can destroy a variance of TBMs, ICBMs, or LYBNWs, but it cannot target; air-breathing threats, cruise missiles, and unmanned aircraft. A variant of other air defense weapon systems must support the THAAD system's defense. The second limitation comparable to the Patriot is mobility. The system must be stationary for it to engage any threat, and a drop of air defense coverage could result in a successful attack by LYBNWs. Which leads to the final limitation and that is the number of THAAD system. There are currently only seven systems within the air defense branch, and two of them are on critical missions.

Overall, the Army air defense branch has a wide variety of limitations. Still, the three that hinder it from defeating the new emergent threats are equipment, mobility, and reliance on human

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[53] US Army, Army Techniques Publication (ATP) 3-01.91, *Terminal High Altitude Defense (THAAD) Techniques* (Washington, DC: Government Printing Office, 2013), 1-4.

[54] Ibid., 5-5.

[55] Ibid., A-2.

processing of engagements. The American adversaries acknowledge that they will not beat America in a conventional conflict war. For the American adversaries to win, they have invested in advanced missile capabilities such as LYBNWs. The American adversary's increase in missile numbers and capabilities results in the threats the air defense branch is required to counter being greater than the equipment available to meet the missions and threats.

Furthermore, the nature of the threat compounds when mobility with the other systems is required in order to cover a maneuver force and the necessary transitions between Patriot batteries. Finally, each of the air defense systems mentioned currently needs a human to operate the platform for engagement. Humans have the potential to make mistakes and take the time that could have a negative implication. As the air defense branch and the Army try to solve this complex problem, an intermediate solution they are rolling out is the Army integrated air and missile defense (AIAMD).

Anticipating the Future of Air Defense Platforms (Intermediate Coding and Selecting Core Category)

The first theme that was noticed under the second step of grounded theory was AI integration into air defense to link sensors and decrease engagement time. For Army air defense to effectively protect force generation and maneuver assets, the branch is developing AIAMD.[56] The concept is to integrate sensors and weapons systems across the Army spectrum and combine them into one operating picture through an integrated battle command post (IBCS).[57] The IBCS will provide a single integrated fire control network where data on enemy air threats could be identified and targeted by the proper weapon system. The current software does not allow this to occur, and the only means is through tactical data links or the Link 16 network. The new AIAMD

[56] US Army, "Army Integrated Air and Missile Defense (IAMD)," US Army, accessed December 1, 2020, https://asc.army.mil/web/portfolio-item/ms-aiamd-2/.

[57] Zach Berger, "Integrated Air and Missile Defense Battle Command System (IBCS)," Mission Defense Advocacy Alliance, February 2017, accessed November 25, 2020, https://missiledefense advocacy.org/defense-systems/integrated-air-and-missile-defense-battle-command-system-ibcs/.

data can transmit to the proper unit and engagement authority. The overall result would provide early warning and the decision space to engage threats such as LYBNWs.

A primary example would be the THAAD radar utilizing the sentinel radar to detect the danger of a low yield nuclear threat and target it through a Patriot missile. The new AIAMD allows the integrated fire control network, it offers early engagement of a threat. If the danger can maneuver and bypass the first engagement, it would be facing a layered missile defense of sensors and interceptors. For the Army to increase the layered defense, it needs the assistance of sensors and engagement platforms within the joint domain.

Even though the US Army has a plethora of sensors through IAMD to defeat the emergent threats, the joint forces community as one functioning unit would provide a further advantage. General Martin E. Dempsey said it best when he stated that the Joint Force's greatest strength is the different capabilities it brings to the fight and when it is operating as a whole unit.[58] The joint integrated air and missile defense (JIAMD) vision is currently coming to fruition across the services. The JIAMD concept is similar to the AIAMD with the common air defense picture and fire control network. Any sensors in the joint domain would provide data, target the threat, and add to the maneuver force's layered defense. The joint community tested the JIAMD in June 2019 during Orange Flag, a joint service exercise.[59] An F-35 aircraft was a forward sensor in detecting a missile threat and transmitted the data to the Army's IBCS system.[60] The new IBCS system and the human engagement authority chose the appropriate air defense platform to engage and destroy the threat. Even though the exercise was the first step in

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[58] Gabriel Almodovar, Daniel P. Allmacher, Morgan P. Ames III, and Chad Davies, "Joint Integrated Air and Missile Defense: Simplifying an Increasingly Complex Problem," *Joint Force Quarterly* (1st Quarter 2018): 78-84, accessed November 20, 2020, https://ndupress.ndu.edu/Publications/Article/1412812/joint-integrated-air-and-missile-defense-simplifying-an-increasingly-complex-pr/.

[59] David Axe, "Stealth Surprise! Can the F-35 Take on Cruise and Ballistic Missiles?," *The National Interest*, October 22, 2019, accessed November 25, 2020, https://nationalinterest.org/blog/buzz/stealth-surprise-can-f-35-take-cruise-and-ballistic-missiles-90326.

[60] Ibid.

operational success for the JIAMD network, it must test on other platforms. In the end, the JIAMD still proved that the joint forces could provide long-range layered defense in future conflicts. However, what risk are the joint forces leaders willing to accept in the new JIAMD system?

Leaders within the joint and Army community are in the risk-averse category of prospect theory. For the simple fact, the cost of the IAMD system and risk of failure is low. The current estimated worth of one single IAMD is $4.9 million, and the Army plans to buy six with a final cost of $29.6 million.[61] The purchase of the IAMD is pennies compared to the Army's defense budget set at $191 billion.[62] The IAMD system allows a single piece of equipment to connect to procured and funded air defense equipment. They will enable the Army to have a cost-effective means to combat emerging threats such as LYBNWs versus purchasing all-new air defense weapon platforms. More importantly, if the IAMD system fails, the air defense branch still has platforms that will provide coverage to an extent without an enemy missile impacting the maneuver force. Those air defense systems have demonstrated that they can perform and execute the mission during the war. However, the limited number of air defense assets and the high operational tempo allows the enemy a window of opportunity to have a successful LYBNWs strike. Finally, the concept of human soldiers being in control of the weapon system reduces leaders' fears. The Army spends money, time, and training on the soldiers to build confidence in their decisions during conflict. The military wants to ensure that those soldiers are well equipped to execute their duties and responsibilities. However, humans can make mistakes and take time to

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[61] US Department of Defense Office Inspector General, DODIG-2019-114, *Audit of the Army Integrated Air and Missile Defense Program* (Washington, DC: Department of Defense Inspector General, 2019), accessed November 24, 2020, https://www.dodig.mil/Reports/Audits-and-Evaluations/Article/1939552/audit-of-the-army-integrated-air-and-missile-defense-program-dodig-2019-114/#:~:text=The%20Army%20IAMD%20program%20is,%244.5%20billion%20in%20procurement%20costs.

[62] Aaron Mehta, "Here's the Breakdown of the Pentagon's Budget Request," *Defense News*, March 12, 2019, accessed November 26, 2020, https://www.defensenews.com/smr/federal-budget/2019/03/12/heres-the-breakdown-of-the-pentagons-budget-request/.

process problems and provide a solution. New technological advancements such as AI might be the next step to eliminating errors and losing time.

Anticipating the Future of Artificial Intelligence (Intermediate Coding and Selecting Core Category)

The second theme under intermediate coding was advancements in AI and the speed of accomplishing tasks. One of the simple AI systems currently employed by companies in the civilian sector is the chatbot. The chatbot is an AI that utilizes algorithms to answer questions with solutions or answers with a high probability of success. One prime example would be the google search engine.[63] Once a person types in a topic in the search box, the AI within milliseconds runs a similar algorithm as the MCTS to find your answer. Once the AI observes the solution, it stores the data for potential use for other customers. The application is applied to incorrect answers as well to ensure the AI increases its probability of success. Other similar chatbots are automotive systems on appointment lines or simple customer support for solving problems. The chatbot's entire concept allows the machine to evolve and answer promptly through communication to the customer continuously.

A much more complex AI system in the civilian sector is Watson, an AI that uses machine-learning at the International Business Machine (IBM) company. Watson is a more complex AI because of the mass amounts of data mining, big data storage, and its various uses in many fields. One of those fields is in medical data for cancer patients. Doctors can import their data on a cancer patient into Watson, which the AI would recommend variables and compare other similar treatments.[64] In turn, allow an increase of analysis by the AI Watson on options that

[63] Parul Padney, "Building a Simple Chatbot from Scratch in Python," *Analytic Vidhya*, September 17, 2018, accessed December 2, 2020, https://medium.com/analytics-vidhya/building-a-simple-chatbot-in-python-using-nltk-7c8c8215ac6e.

[64] Margaret Rouse, "IBM Watson Supercomputer," TechTarget Network, June 20, 2018, accessed December 3, 2020, https://searchenterpriseai.techtarget.com/definition/IBM-Watson-supercomputer.

could provide treatments that are not as problematic as chemo and provide positive results. Advances of AI, such as Watson in the civilian sector, will only continuously increase at a gradual pace, which begs the question of AI's status in the American military. What could be the advancements and capabilities with AI in the American military?

In 2018 the Trump administration understood the importance of AI and accelerated the research process. The administration's goal was to develop an AI that could execute specific tasks that a human soldier does daily.[65] When dealing with large sets of data, especially in the intelligence domain, it requires a human to conduct analysis and synthesis. The actions of the human staff require time that is limited in certain situations. The AI would be able to analyze, synthesize, and provide solutions to the leadership within minutes.

Furthermore, the administration recognized that AI could assist in the logistics domain. An AI system would examine data from mechanical or logistical states to determine the need for resupply.[66] A primary example would be a mechanic turning in a vehicle or weapon system report with ongoing issues. The AI would use "big data" to evaluate the problem's source trends or patterns. The AI will also offer a solution or just order and promptly ship the part to the unit. The process will eliminate the need for a human diagnostic that is timely versus the practical steps of AI. Other visions of AI advancements in the American military are in the air defense domain.

The new AI system that the US Army is trying to develop is the TITAN communication node. TITAN will be responsible for communicating with an AI onboard a satellite within a

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[65] Jefferey Smith, "Trump Administration Accelerates Military Study of Artificial Intelligence," Center for Public Integrity, April 26, 2018, accessed December 2, 2020, https://publicintegrity.org/national-security/trump-administration-accelerates-military-study-of-artificial-intelligence/?gclid=Cj0KCQiAk53-BRD0ARIsAJuNhpvoHl9UOVRqUvubcFEH9SQjVb7Kir3A44TrKDjiQKQzKxtY8WAr0iIaAonXEALw_wcB.

[66] Ibid.

specific theater.[67] The chosen theater satellite provides imagery depicting missile threats such as LYBNWs. The new TITAN system will replace current out of date technology that takes days to upload and download the imagery.[68] Human operators must sort through the data to determine what the imagery shows and develop solutions with the current satellite technology. The new AI system on the TITAN and satellite will decrease the upload and download time and provide options to counter the missile threat, allowing more decision space for the leadership to choose the appropriate means to destroy the threat before it evades detection.[69] The new TITAN system will allow a significant technological advantage on the battlefield for America. However, the American military is still not exploiting AI's full potential on integration and autonomous level.

Recommendation for Artificial Intelligence (Advanced Coding and Theoretical Imagination)

The final step in grounded theory identified that AI would be the necessary system to defeat LYBNWs by being autonomous air defense platform. The immediate recommended step for the Army and the joint community is to pursue the full integration of AI into the IAMD platforms to defeat threats including LYBNWs. Though American adversaries would use LYBNWs to stop American maneuver forces because of their rapid response time and destruction, the incorporation of AI technology gains back the time space advantage enabling to destroy incoming threats such as LYBNWs. Critics of AI integration will express concern that human operators can execute the same task. The process to discriminate targets takes time, focus,

[67] Nathan Strout, "How the Army Plans to Use Space and Artificial Intelligence to Hit Deep Targets Quickly," *Defense News,* August 5, 2020, accessed December 2, 2020, https://www.defensenews.com/digital-show-dailies/smd/2020/08/05/how-the-army-plans-to-use-space-and-artificial-intelligence-to-hit-deep-targets-quickly/.

[68] Strout, "How the Army Plans to Use Space and Artificial Intelligence to Hit Deep Targets Quickly."

[69] Nathan Strout, "What the Army's TITAN Program Means to Multidomain Operations," C4ISRNET, June 9, 2020, accessed December 2, 2020, https://www.c4isrnet.com/battlefield-tech/it-networks/2020/06/09/what-the-armys-titan-program-means-to-multidomain-operations/.

and a mental sprint to complete this undertaking. An AI integrated system would remain focused with no mental exhaustion and a reduced time to execute the task, especially in a threat saturated environment. A study in 2019 found that an AI could analyze documents in 26 seconds versus the human test subjects' 92-minute time.[70] Not to mention the AI systems' accuracy of the task was 100 percent.[71] The AI time reduction to determine the threat lessens the mental sprint for all the operators within the AIAMD or JIAMD. Allowing operators, the decision space needed to posture their systems to defeat the LYBNWs threat.

The next positive aspect of an integrated AI system involves the targeting of threats. Applying an AI with an algorithm like the Beta Tree or Monte Carlo will create multiple built-in branch plans to provide an optimal solution to defeat LYBNWs.[72] In a situation where a new threat emerges, the AI analyzes the data and provides new solutions. Once the system has a successful engage, the AI classifies the option as a success and stores it for potential use in the future. Furthermore, the AI will expedite the request process through the Joint Kill chain. The operators must currently communicate through their command chain to the air force's air operation Center to engage specific air threats.[73] The request process is expedited but not as immediate as AI is in this process. AI would send the request directly to the proper authorization authority with the required personnel on the communication line and get the approval for the engagement. The operator will order engagement to destroy the incoming threat with the right weapon platform promptly.[74] Though humans can build branch plans, assess new threats, and

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[70] Andrey Sergeenkov, "Artificial Intelligence is Becoming Better than Human Expertise," Hackernoon, March 1, 2019, accessed December 12, 2020, https://hackernoon.com/artificial-intelligence-is-becoming-better-than-human-expertise-16903f4fc3c0.

[71] Ibid.

[72] Russel and Norvig, *Artificial Intelligence*, 162.

[73] Northrop Grumman, "Understanding the Joint Kill Chain," Webcast, C4ISRNet, October 14, 2020, accessed December 27, 2020, https://www.c4isrnet.com/native/northrop-grumman/2020/10/09/webcast-understanding-the-joint-kill-chain/.

[74] Ibid.

notify the proper authority for the engagement, manual processes take time that is not available for missile threats such as LYBNWs. AI reduces the time and makes the process rapid and efficient compared to humans.

The final optimistic aspect of an integrated AI into the IAMD network is the potential to have stable and dependable communication platforms. In a situation where the enemy can launch LYBNWs without hesitation, communication is critical in stopping the threat. The AI can analyze data and provide solutions on the optimum communication networks and platforms required to execute the air defense mission.[75] Once again, AI will use past performance data in the new changing environment to answer effectively. More importantly, the AI will warn the communication operators of potential malfunctions or attacks and offer resolutions to maintain the network. Human communication operators will fix or manipulate the network before failure resulting in the free flow of correspondence to be unimpeded between the air defense fire unit and the engagement authority. Critics will once again state that humans can execute the same task as AI. The counter to the argument is comparing the time and speed of human and AI. The AI will outperform and accomplish the job promptly. Begs the question, is the Army and joint community utilizing AI properly to defeat LYBNWs?[76]

The Army and the joint community are not unleashing AI's full potential or capabilities in the air defense domain. Human operators are the ones in control of making the decisions when authorizing engagement, selection of the system, and targeting. Once more, the process takes time that cannot be allowed when facing LYBNWs. Leading to the final recommendation is to have an

[75] Diomedes Kastanis, "How AI Will Lead to Self-Healing Mobile Networks," VentureBeat, March 1, 2017, accessed December 12, 2020, https://venturebeat.com/2017/03/01/how-ai-will-lead-to-self-healing-mobile-networks/.

[76] Jackson Barnett, "Military's AI Hub Is Ready to Think About War, Gen. Shanahan Says on Last Day at Pentagon," Fedscoop, May 29, 2020, accessed December 27, 2020, https://www.fedscoop.com/jack-shanahan-retiring-jaic-warfare/.

autonomous artificial intelligent air defense system (AAADS). Three critical elements are needed to allow the AAADS to be fully operational.

First is a missile defense platform that can engage a wide range of threats incorporated into the existing air defense architecture to have layered protection. Meanwhile, allowing the new AAADS to slowly take over the air defense mission and maintain the security bubble, eventually solving the current issue of minimal systems across the air defense branch against the high demand of assignments.[77]

Second is dedicated satellites to the AAADS to give real-time battlefield information. The AAADS would need access to those satellites to upload and download data to determine the best possible solution to counter a potential threat. Meanwhile, continuously building out numerous branch plans against multiple threats providing a repository of near-instantaneous response for future or potential scenarios.

Third, there are no human operators involved in the process except maintaining the AAADS. Having no human operators allows the AI to reach its full potential and provide the most favorable air defense coverage against maneuverable missiles, hypersonic threats, and most importantly, LYBNWs. Not having a human operator allows the AI to engage once LYBNW is launched early in the boost phase or within the transition to the midcourse phase, potentially destroying it over the enemy territory (reference Appendix E).[78] Furthermore, the AAADS big data would allow it to calculate the position to destroy the LYBNWs over enemy maneuver forces, ultimately killing two birds with one stone. Even though AI and the recommended AAADS would offer many advantages, leaders would be critical of the concept.

[77] Bowman, Gabel, and Smits, "Iran Attack Highlights US Missile Defense Vulnerability."

[78] Tommy Reed, "The 3 Major Phases of Effective Missile Defense Systems," Microwave & RF, September 20, 2017, accessed December 13, 2020, https://www.mwrf.com/markets/defense/article/21848658/the-3-major-phases-of-effective-missile-defense-systems.

The US Army is missing the mark by combining AI and drone technology into an air defense platform. Currently, the US Army faces an air defense system shortage when facing multiple threats. The numerous threats require a variety of air defense platforms the Army does not currently possess. The United States needs to move to an all-inclusive AI/drone platform. The system would be autonomous with the capability to engage multiple threats from ICBMs to cruise missiles. The drones would support in the protection of the air defense asset against ground and aerial threats.

Figure 5. Potential for an AAADS Model. Amin Akhshi, "M130 Abrams, 108th Air Defense Artillery Brigade," Pintrest, accessed February 11, 2021, https://www.pinterest.com/pin/745697650772907544/.

Critics opposing an autonomous AI air defense system will make two main arguments. The first contention is that the Patriot air defense system was semi-autonomous during Operation Iraq Freedom (OIF) in 2003 when it shot down two friendly aircraft. Contenders will argue that the same scenario from OIF will occur in a future fight if the system is fully autonomous. The rebuttal is simple, modern technology is much better.. The software that the Patriot system utilized in OIF was new for its time. The program within the software had limited data confined to the Patriot system. A fully autonomous AI air defense system will have access to big data through the dedicated satellites or information nodes. Having access to a plethora of information nodes will allow the system to identify threats, target, and destroy them efficiently.

The second argument is that a human threat can hack the AI and control the autonomous air defense system. In addition to playing on the fear of the machine being turned on American forces and shooting down friendly aircraft, challengers provide data that shows old and current systems succumbing to hackers by American advisors. The counter-argument is incorporation of AI enabled network defense as a failsafe program within the system to mitigate such threats.[79] Furthermore, programmers can run the AI through hacking iterations to build its data bank options when facing this threat before fielding. Once deployed, the programs will continue to analyze new hackers' methods and provide the AI data. Allowing the autonomous AI air defense system, the means to detect, warn and counter any hacking threat. Ultimately, none of that matters if the leaders of the American military stop being risk-averse.

Implications of integration or autonomous AI's make leaders in the Army and the joint community risk-averse. Per prospect theory, the leadership has occurred to many win sets and are afraid to assume the risk.[80] The only time the leadership will take risk is when a loss has occurred, and the only option is to accept risk. An excellent example of this would be a maneuver force eliminated by LYBNWs followed by a hasty insertion of an AI air defense weapon system. The new system will have many issues and have an increased chance of failure because of the pressure and necessary fielding. For leadership to accept an integrated AI or autonomous system requires specific actions. The first action is building and showing the AI's algorithm to be a defensive capability against many threats, specifically against LYBNWs. Tests and evaluations in multiple scenarios will reveal that AI will likely remain in its operational capacity and be a

[79] Nathan Eddy, "Use of Defensive AI Against Cyberattacks Grows," Security Boulevard, April 22, 2021, accessed May 4, 2021, https://securityboulevard.com/2021/04/use-of-defensive-ai-against-cyberattacks-grows/.

[80] Daniel Kahneman and Amos Tversky, "Prospect Theory: An Analysis of Decision under Risk," *Econometrica* 47, no. 2 (March 1979): 292.

tremendous asset to the Army and the joint community. Furthermore, the AI would frequently play out situations to build its data banks and show leadership the outcomes. Meanwhile, reducing the fears of AI becoming a dangerous threat or improperly engaging targets.

The second action that must occur is a fail-safe built into the AI system. Department of Defense Directive (DODD) 3000.09 requires AI to be monitored by human operators.[81] The directive allows leadership to have a human operator in control of the AI to initiate shutdown procedures in system errors or malfunctions. The new autonomous AI system must have a fail-safe that allows a human operator to intervene to shut down the system as a whole or stop an engagement. A fail-safe allows the new AI system to fall under the DODD 3000.9 requirements and adheres to some of the leadership's concerns with some human intervention.

The final action deals with the risk acceptance by leaders in a losing scenario. Leaders will need to see the results of not capitalizing on the new technological advancements from the American enemy's perspective. Countries like China and Russia have begun developing AI weapon systems and plan to use them in future conflicts.[82] Leaders will need to see the results of that conflict without AI to fight on behalf of America. Additionally, leaders will need to see how they will be willing to take higher risks in the future scenario to win and the increased potential of devastating results. One potential future scenario would be a massive loss by America and leadership, deciding to have an AI operate all weapon systems. AI would determine the current factors and decide the only way to win is a nuclear offensive. According to prospect theory, leadership would allow the nuclear option because of the guaranteed loss.[83] Results of decisions

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[81] US Department of Defense, Department of Defense Directive (DODD), 3000.09, *Autonomy in Weapon Systems* (Washington, DC: Government Publishing Office, 2012, Incorporating Change 1, May 2017).

[82] Samuel Bendett and Elsa Kania, "The Resilience of Sino-Russian High-Tech Cooperation," *War on the Rocks*, August 12, 2020, accessed December 26, 2020, https://warontherocks.com/2020/08/the-resilience-of-sino-russian-high-tech-cooperation/.

[83] Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus, and Giroux, 2011), 280.

in this future scenario would be catastrophic on a global level. The evidence provided would stir leaders to assume more risk currently to avoid hazardous choices in the future.

Conclusion

In conclusion, history shows that technological advances enable warfare and provide a time space advantage and that countries who invest in emergent technology and incorporate it into current systems gain advantage in conflict. The progression of the cannon, airpower, and nuclear revolution as example provided the means for countries to be successful. More importantly, the nuclear revolution's progression has led to the technological advancement of LYBNWs that threatens American forces. Current air defense weapon systems SHORAD, Patriot, and THAAD have some capability against current missile threats. However, the high operational tempo and the insufficient number of systems, and the emergence of LYBNWs creates windows of opportunity for the enemy to strike the American maneuver force. The American military believes that the windows of opportunity can be closed through linking sensors and networks together through IAMD. The IAMD system provides a temporary sense of protection but ultimately falls short should air defense shortages remain. Still, the United States faces a loss in a large-scale fight where the maneuver forces are continually moving, straining the air defense assets to relocate, meanwhile combating a variation of hypersonic missiles, TBMs, and LYBNWs. The only way to win the fight against hypersonic missiles, TBMs, and LYBNWs is by integrating AI into air defense.

AI is the next technological weapon for America to succeed in future conflicts. AI would provide optimal capabilities to target, engage, and destroy emerging threats such as LYBNWs. The AI system has an exceeding ability to identify a target and utilize the proper missile to eliminate a threat comparison to human operators. Integration of AI into the current IAMD is the first step to deter and defeat emerging aerial threats, especially LYBNWs. However, the apparent path to defeat LYBNWs in a large-scale fight is to develop and test the new AAADS. The system will have the ability to track numerous targets, expedite engagement, and protect the maneuver force. The AAADS ultimately allows the American military to succeed in the future large-scale fight against a variation of hypersonic missiles, TBMs, and LYBNWs.

Appendix A
Avenger on HMMWV--High Mobility Multi-Purpose Wheeled Vehicle

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Appendix B
Sentinel Radar

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Appendix C
How Patriot Missiles Work

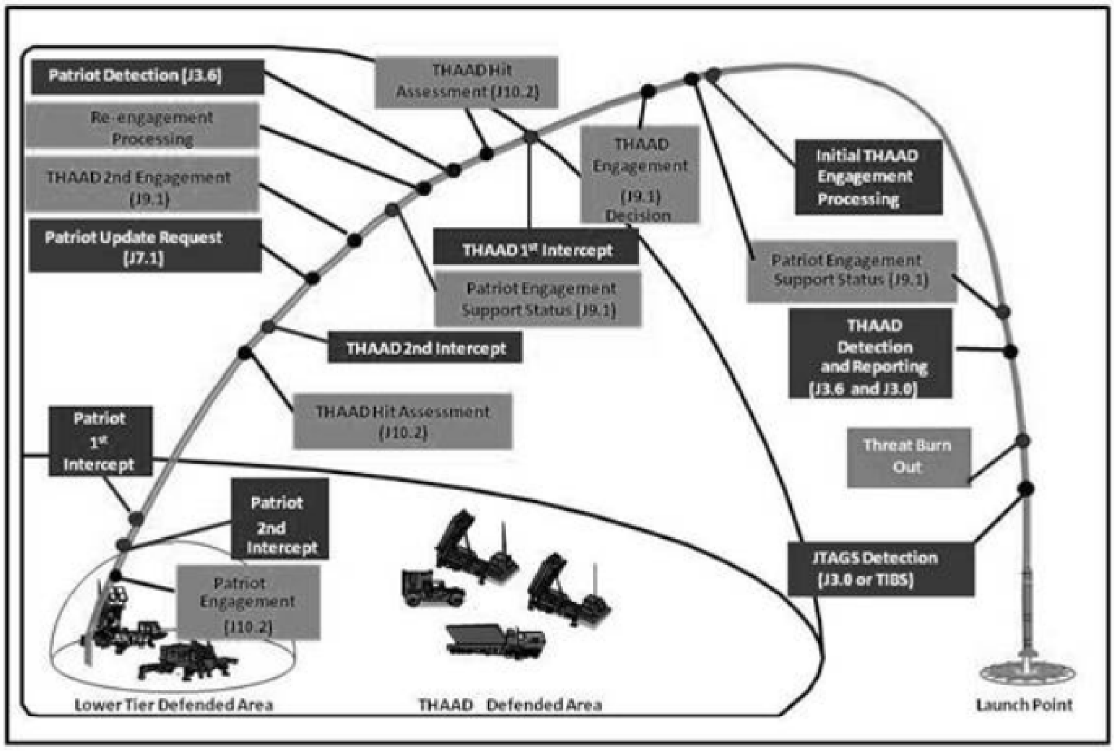
DUE TO COPYRIGHT RESTRICTIONS,

IMAGES ARE NOT INCLUDED

IN THIS ELECTRONIC EDITION.

Marshall Brain, “How Patriot Missiles Work,” How Stuff Works, accessed November 20, 2020, https://science.howstuffworks.com/patriot-missile.htm.

Appendix D
THAAD Diagram



US Department of the Army, Army Techniques Publication (ATP) 3-01.91, *Terminal High Altitude Defense (THAAD) Techniques* (Washington, DC: Government Printing Office, 2013), 5-5.

Appendix E
IAMD

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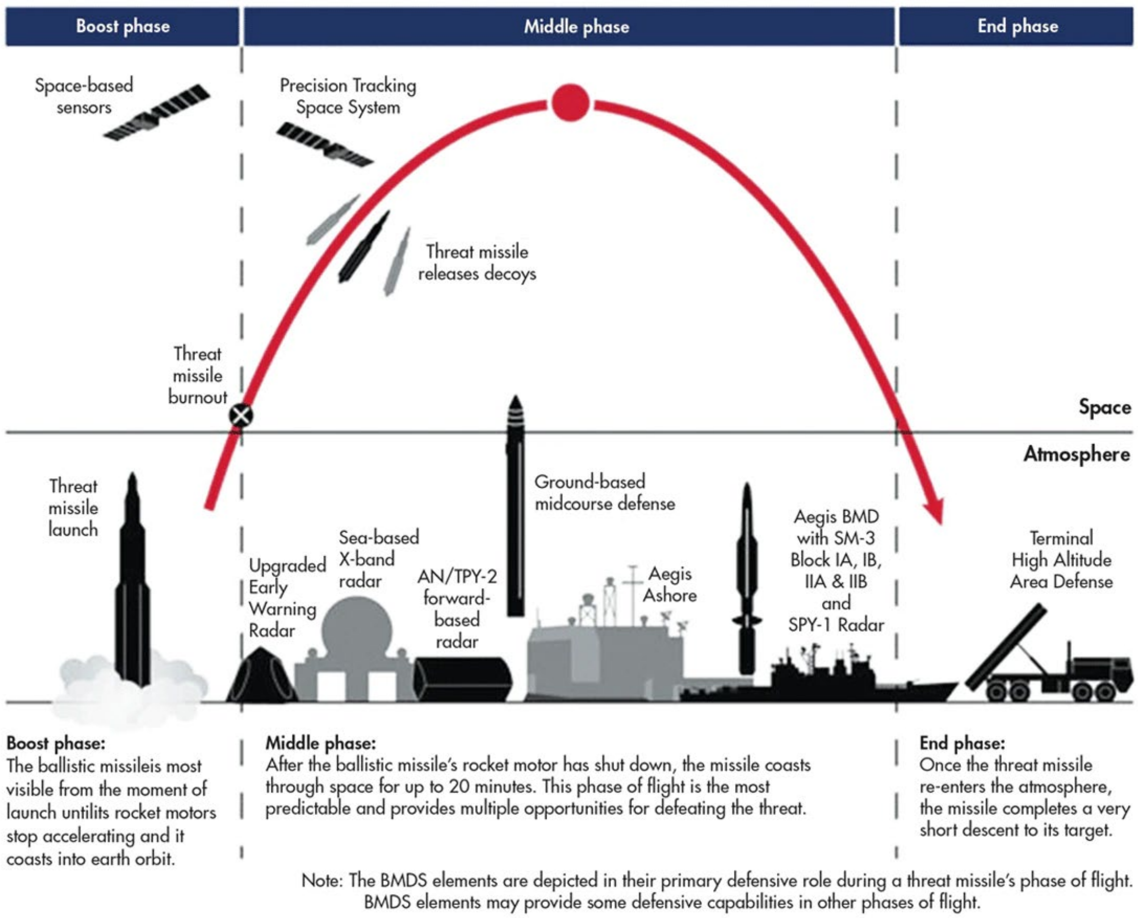
Appendix F
Missile Launch Phases



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