

ARTIFICIAL INTELLIGENCE: WINNING THE TALENT MANAGEMENT RACE

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MASTER OF MILITARY ART AND SCIENCE
Information Advantage Scholars

by

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ABSTRACT

ARTIFICIAL INTELLIGENCE: WINNING THE TALENT MANAGEMENT RACE,
by Yvette Kushmerick, 109 pages.

Artificial Intelligence has the potential to “change the nature of war.” The race to harness AI for economic, industrial, social, and, most importantly, military use, has the potential to shift the balance of power between the U.S. and China and fundamentally change the post-World War II international order. The U.S. National Security Commission on Artificial Intelligence concluded that the “holy grail” of Artificial Intelligence breakthroughs is talent, and the commission regards talent as the most essential requirement to succeeding in the AI race with China. The U.S. Department of Defense is not prepared for the pending Artificial Intelligence military revolution and is not postured to compete with China due to an insufficient talent pool. The race to break adversary cryptographic systems, the race for the atomic bomb, and the space race offer lessons to shape the national Artificial Intelligence initiative and set conditions to gain a marked advantage in information warfare. This paper explores these historical examples in a multiple case study analysis to discover talent management tenets the Department of Defense can employ to cultivate an Artificial Intelligence-ready workforce.

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ACRONYMS

AI	Artificial Intelligence
C4ISR	Command, Control, Communications, Computers (C4) Intelligence, Surveillance and Reconnaissance (ISR)
CDAO	Chief Digital and Artificial Intelligence Officer
CoSTEM	Committee on Science, Technology, Engineering and Math Education
DoD	Department of Defense
IoT	Internet of Things
IW	Information Warfare
JAIC	Joint Artificial Intelligence Center
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NDEA	National Defense Education Act
NSCAI	National Security Commission on Artificial Intelligence
PLA	People's Liberation Army
PRC	People's Republic of China
STEM	Science, Technology, Engineering, and Mathematics
UK	United Kingdom
U.S.	United States
USSR	Union of Soviet Socialist Republics
WWII	World War II

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CHAPTER 1

INTRODUCTION

Tech advances like Artificial Intelligence are changing the face and the pace of warfare. Artificial Intelligence and related technologies will give us both an information and an operational edge... and that means a strategic advantage.

—Secretary of Defense, Lloyd J. Austin III, Remarks at the
Global Emerging Technology Summit of The National
Security Commission on Artificial Intelligence

Background

In 1948, British logician and computer pioneer, Alan M. Turing, delivered a conceptual framework for Artificial Intelligence (AI) in a report titled “Intelligent Machinery.”¹ In seventy-four years, AI transformed from a theoretical concept, which Alan Turing described as logical computational inputs, to a universal machine that teaches its own instructions for self-modification.² Specifically, Turing stated that “it is possible to make machinery to imitate any small part of a man, to include some sort of ‘electronic brain.’”³ Today, AI revolutionized everyday life for over seven billion humans from providing the fastest route to the local bakery and the best song that meets consumer preference to voice-activated assistants and self-driving cars.⁴ The U.S. Department of Defense (DoD) defines AI as the ability of machines to perform tasks that

¹ “Intelligent Machinery,” Allen Turing, 1948, <https://weightagnostic.github.io/papers/turing1948.pdf>.

² Ibid., 8.

³ Ibid., 8-9.

⁴ Christian Brose, *The Kill Chain: Defending America in the Future of High-Tech Warfare* (New York: Hachette Books, 2020).

normally require human intelligence.⁵ Recognizing the profound impact AI has as a military application, in what may be deemed a military revolution due to its potential to fundamentally change the character of war, led to a technological race between international powers, in particular between the United States (U.S.) and the People's Republic of China (PRC).⁶ The competition for AI leadership and its outcome will have significant consequences on international politics.⁷

President Xi Jinping addressed the 19th National Congress of the Communist Party of China in October 2017, during which he exclaimed the PRC will promote “further integration of the internet, big data, and AI with the real economy.”⁸ Since then, the PLA sought the ways and means to achieve its end-state of being a world-class force by 2050.⁹ China's “New Generation Artificial Intelligence Development Plan” states that

⁵ U.S. Department of Defense (DoD), *Summary of the 2018 Department of Defense Artificial Intelligence Strategy: Harnessing AI to Advance Our Security and Prosperity* (Washington, DC: DoD, February 12, 2019), 5, <https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF>.

⁶ Michael C. Horowitz, Gregory C. Allen, Elsa B. Kania, and Paul Scharre, *Strategic Competition in an Era of Artificial Intelligence* (Washington, DC: Center for a New American Security, July 25, 2018), 3, <https://www.cnas.org/publications/reports/strategic-competition-in-an-era-of-artificial-intelligence>.

⁷ Ibid., 9.

⁸ Xi Jinping, “Secure a Decisive Victory in Building a Moderately Prosperous Society in All Respects and Strive for the Great Success of Socialism with Chinese Characteristics for a New Era,” (delivered at the 19th National Congress of the Communist Party of China, October 18, 2017), http://www.xinhuanet.com/english/download/Xi_Jinping's_report_at_19th_CPC_National_Congress.pdf.

⁹ Ibid.

“AI has become a new focus of international competition.”¹⁰ The PLA and the PRC’s defense industrial base have been pursuing significant investments in swarming, robotics, autonomous systems, and other military applications for AI to achieve its People’s War concept of “Intelligentized Warfare.”¹¹ According to the U.S. National Security Commission on Artificial Intelligence (NSCAI), the DoD AI Strategy, and China’s ‘New Generation Artificial Intelligence Development Plan’ (2017), the crux of its national AI capability is the cultivation of talent pools in the fields of Science, Technology, Engineering, and Mathematics (STEM).¹²

The challenges to gaining and maintaining a technological advantage over a competitor in the AI race are not unique from a historical perspective. At the start of World War II, the U.S. fell behind peer competitors in cryptanalytics. However, the U.S. prevailed over the Axis Powers by identifying the gap, discovering the right talent, creating the technology to support the talent, and deciphering the German and Japanese

¹⁰ Graham Webster, Rogier Creemers, Paul Triolo, and Elsa Kania, “Full Translation: China’s ‘New Generation Artificial Intelligence Development Plan’ (2017),” *New America*, August 1, 2017, <https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/>.

¹¹ Elsa B. Kania, “*AI Weapons*” In *Chinese Military Innovation* (Washington, DC: The Brookings Institution, April 2020), https://www.brookings.edu/wp-content/uploads/2020/04/FP_20200427_ai_weapons_kania.pdf.

¹² National Security Commission on Artificial Intelligence (NSCAI), *Final Report: National Security Commission on Artificial Intelligence* (Washington, DC: NSCAI, March 19, 2021), <https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf>; DoD, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*, 7; Webster et al., “China’s ‘New Generation Artificial Intelligence Development Plan’ (2017).”

codes.¹³ Perhaps the most consequential of the examples was the race for the atomic bomb, renowned as the Manhattan Project. The success of the Manhattan Project had immediate and strategic implications. The U.S. Space Race with the Soviet Union in the 1950s and 1960s in which both sides sought to achieve superior spaceflight capabilities called for a national reckoning for gifted and talented mathematics and science students. A synergistic, whole-of-government approach is required for the U.S. to maintain a competitive advantage over China in the AI race.

Problem Statement

According to NSCAI, the U.S. has not grasped the profound influence AI will have on national security, nor is the U.S. is prepared to compete in the AI era.¹⁴

According to Secretary of Defense, Lloyd Austin, during his remarks at the Global Emerging Technology Summit of The National Security Commission on Artificial Intelligence:

China's leaders have made clear they intend to be globally dominant in AI by the year 2030. Beijing already talks about using AI for a range of missions, from surveillance to cyberattacks to autonomous weapons. In the AI realm as in many others, we understand that China is our pacing challenge. We're going to compete to win."¹⁵

¹³ Jennifer Wilcox, *Sharing the Burden: Women in Cryptology during World War II* (Fort George G. Meade, MD: Center for Cryptologic History, National Security Agency, 1998), https://www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/sharing_the_burden.pdf; Liza Mundy, *Code Girls: The Untold Story of the American Women Code Breakers of World War II* (New York, NY: Hachette Books, 2018), 12.

¹⁴ NSCAI, *National Security Commission on Artificial Intelligence*, 1.

¹⁵ Lloyd J. Austin III, "Secretary of Defense Austin Remarks at the Global Emerging Technology Summit of The National Security Commission on Artificial Intelligence (As Delivered)," Transcript, July 13, 2021, <https://www.defense.gov/News/>

Since 2017, China rapidly caught up with the U.S. in AI-related patent applications, publications, and STEM programs in higher learning institutions further lending to strategic competition between the U.S. and China to claim leadership in AI.¹⁶ The race to harness AI for economic, industrial, social, and, most importantly, military use has the potential to shift the balance of power between the U.S. and China and fundamentally change the post-World War II international order.¹⁷

According to official U.S. government publications and scholarly articles on the strategic competition between the U.S. and China, the race between the U.S. and China for AI leadership will largely manifest itself in the competition for talents.¹⁸ Finally, according to the NSCAI, the holy grail of AI breakthroughs is rare talent. The commission regards talent as the most essential requirement for succeeding in the AI race with China because “it drives the creation and management of all other elements.”¹⁹

Purpose of the Study

The purpose of this study is to discover some of the principles that lead to transformational government innovations to achieve superior performance in a technological race. In this case, the race is for AI leadership between the U.S. and China.

Transcripts/Transcript/Article/2692943/secretary-of-defense-austin-remarks-at-the-global-emerging-technology-summit-of/.

¹⁶ Wang You and Chen Dingding, “Rising Sino-U.S. Competition in Artificial Intelligence,” *China Quarterly of International Strategic Studies* 4. no. 2 (2018): 246, <https://doi.org/10.1142/S2377740018500148>.

¹⁷ Ibid., 242.

¹⁸ Ibid., 255.

¹⁹ NSCAI, *National Security Commission on Artificial Intelligence*, 32.

According to the NSCAI, the greatest impediment to being AI-ready is a talent deficit.²⁰ Specifically, the NSCAI asserts that “the human talent deficit is the government’s most conspicuous AI deficit and the single greatest inhibitor to buying, building, and fielding AI-enabled technologies for national security purposes.”²¹ Thus, the study aims to understand what talent management principles support the U.S. in achieving a technological advantage over China in the field of AI. Specifically, are there lessons to be gleaned from historical technological races, cryptanalysis during WWII, the race for the atomic bomb, and the space race, that can inform how the U.S. Government can transform talent management practices to prevail as the AI leader?

Research Questions

The research questions are based on what both the U.S. and China perceive to be the most influential aspect of achieving a competitive advantage in the AI race: talent. The primary research question is how can the U.S. apply lessons learned on talent management from historical technological races—cryptanalysis during WWII, the race for the atomic bomb, and the space race—to maintain the competitive edge in the AI race. The secondary research questions are what talent management programs can be employed to support the U.S. in the AI race at the strategic level and how can the U.S. military overcome talent management barriers to foster the national AI strategy?

²⁰ NSCAI, *National Security Commission on Artificial Intelligence*, 10.

²¹ *Ibid.*, 3.

Assumptions

Innovative technological development and adaptation are challenging to measure.²² One assumption is that technical patents and publications equal an advantage in AI. While conducting statistical analysis on publications, there is an assumption that more publications on behalf of one country mean better qualitative data. Both the U.S. and China recently published AI strategies.²³ However, there is not enough published quantifiable data to support whether the strategies are meeting roadmap milestones.

Furthermore, China's big data infrastructure and intelligence collection capabilities on its own population signify its ability to harness the capability in an information warfare advantage over the U.S. China's ability to conduct military-civilian fusion to achieve its strategic military end-state equates to a personnel talent imbalance due to scope of population sizes in each country. There is a substantial workforce in China to conduct trivial tasks in support of creating AI algorithms for self-modifying computers to meet President Xi's vision. It is an assumption that the larger workforce dedicated to AI production will equal ingenuity, a requirement to prevail in the AI race.

Definition of Terms

The definition of terms below will be used throughout this study.

²² Philip Cross, "Innovation: Elusive, Hard to Measure but Essential," *National Review*, December 30, 2020, <https://www.nationalreview.com/2020/12/innovation-elusive-hard-to-measure-but-essential/>.

²³ U.S. President, Executive Order 13859, *Maintaining American Leadership in Artificial Intelligence* (Washington, DC: Executive Office of the President, February 11, 2019), <https://www.federalregister.gov/documents/2019/02/14/2019-02544/maintaining-american-leadership-in-artificial-intelligence>.

Artificial Intelligence. “the ability of machines to perform tasks that normally require human intelligence.”²⁴

Artificial Intelligence Workforce. “those who have an artificial intelligence or artificial intelligence-related bachelor’s or higher degree or who work in an artificial intelligence or artificial intelligence-related occupation.”²⁵

Case Study. “a qualitative research methodology that studies a ‘bounded system’ with the focus on a particular case. A qualitative case study provides an in-depth study of this system based on a diverse array of data collection materials and the researcher situates the case within its larger context.”²⁶

Diversity. “the inclusion of individuals representing more than one national origin, color, religion, socioeconomic stratum, and sexual orientation.”²⁷

Information warfare. “any action to deny, exploit, corrupt or destroy the enemy’s information and its functions; protecting the U.S. against those actions and exploiting U.S. military formation functions.”²⁸

²⁴ DoD, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*, 5.

²⁵ National Science Board, *Science and Engineering Indicators 2019* (Arlington, VA: National Science Foundation, September 4, 2019), <https://ncses.nsf.gov/pubs/nsb20197>.

²⁶ John W. Creswell, *Qualitative Inquiry and Research Design: Choose Among Five Approaches* (Thousand Oaks, CA: Sage Publications, 2007), 244.

²⁷ “Diversity,” Dictionary.com, accessed April 1, 2022, <https://www.dictionary.com/browse/diversity>.

²⁸ Colonel Andrew Borden, USAF, “What is Information Warfare?” *Air and Space Power Journal*, accessed October 10, 2021, 1, <https://www.airuniversity.af.edu/Portals/10/ASPJ/journals/Chronicles/borden.pdf>.

Military innovation. “change in how militaries prepare for, fight, and win wars.”²⁹

Military revolution. uncontrollable, unpredictable, and unforeseeable changes in politics and society, leading to a revolution that fundamentally changes the character of war.³⁰

Recruitment. “to seek to enroll.”³¹

Revolution in military affairs. “a compilation of tactical, organizational, doctrinal, and technological innovations to implement a new conceptual approach to warfare.”³²

Sense of Urgency. “taking bold action to remove sources of complacency.”³³

Talent management. “a system that systematically identifies the critical positions which contribute to the sustainable competitive advantage of an organization and supply appropriate manpower for these positions. This definition of talent management focuses on the concept of talent pools that are valuable, rare, and hard-to-imitate.”³⁴

²⁹ Andrew L. Ross, “On Military Innovation: Toward an Analytical Framework,” (Policy Brief No. 1, Study of Innovation and Technology in China, University of California Institute on Global Conflict and Cooperation, San Diego, CA, September 1, 2010), 1, <https://escholarship.org/uc/item/3d0795p8>.

³⁰ MacGregor Knox and Williamson Murray. *The Dynamics of Military Revolution* (Cambridge, UK: Cambridge University Press, 2001), 6-7.

³¹ Merriam-Webster, Incorporated, “Recruit,” Merriam-Webster, accessed April 18, 2022, <https://www.merriam-webster.com/dictionary/recruit>.

³² Knox and Murray, *The Dynamics of Military Revolution*, 12.

³³ John P. Kotter, *Leading Change* (Boston, MA: Harvard Business Review Press, 2012).

³⁴ Sajjad Waheed, Abdulhalim Zaim and Halil Zaim, “Talent Management in Four Stages,” *The USV Annals of Economics and Public Administration* 12, no. 1 (June 2012). 131, <https://www.semanticscholar.org/paper/TALENT-MANAGEMENT-IN-FOUR-STAGES-Waheed-Zaim/ef7f7e89f2f11d11aba792e73eb054f4ff7c294f>.

Scope

The paper explores talent management principles from three case studies: the race to break cryptographic systems during WWII, the race for the atomic bomb, and the space race in the 1960s. During each of these historical technological milestones, the U.S. and its allies assembled brilliant minds to overcome a national security challenge. The technological innovations shortened WWII, created parity in space exploration, and shaped international relations. During each of these historical examples, the U.S. began the technological race from the relative disadvantage behind an adversary but overcame and seized the initiative.

Today, the U.S. is in an AI race with China.³⁵ National AI strategies for both countries reveal that talent is the greatest challenge to operationalizing AI for national security.³⁶ This paper does not uncover current AI programs in the U.S. or China. The study remains specific to the three above case studies in relation to the AI race between the U.S. and China. The study focuses on published U.S. and PRC national AI strategies, not specific AI technologies. Finally, talent management in this study is related to pools of people, not specific individuals in current AI programs.

Limitations

The primary limitation in conducting this study is the time constraint of only nine months during Command and General Staff Officer's Course. Additionally, the source

³⁵ Michelle Fox, "U.S. in 'Arms Race' with China for A.I. Tech and Talent, Says Billionaire Tech Investor," *CNBC*, September 12, 2017, <https://www.cnbc.com/2017/09/12/us-china-compete-for-a-i-tech-and-talent-says-billionaire-investor.html>.

³⁶ NSCAI, *National Security Commission on Artificial Intelligence*.

for research data comes from only open-source methods. In the last four years, the U.S. and China published national strategies to attain and maintain international leadership in the race for AI. There is currently not enough published unclassified quantifiable data to support whether the strategies are meeting roadmap milestones. There has been an explosion in the number of scholarly articles on the usage of AI, including AI for talent management. However, there are few articles on the scientists and statisticians behind the creation of AI programs. There is no means to compare the interview input from the scientists behind the three case studies with input from AI experts in the field. Finally, there is not enough information to identify whether tailored university recruitment of scientists during the space race was a common practice during the 1950s and 1960s.

Delimitations

Delimitations are limitations the authors consciously establish.³⁷ The three case studies researched in this study are cryptanalysis during WWII, the race for the atomic bomb, and the space race. These case studies were selected by examining the nature of AI from the algorithm creator's viewpoint, not the usage of the technology. Research in the field of talent management to build a cadre of proficient AI algorithm creators and proselytizers in the U.S. and China is limited. This study intentionally focuses on the AI strategies for the U.S. and China and how the two countries harness talent management to propel their strategies. The nature of AI requires problem-solving, computer science expertise, and patience to conduct tedious work. Additionally, research to compare the

³⁷ Dimitrios Theofanidis and Antigoni Fountouki, "Limitations and Delimitations in the Research Process," *Perioperative Nursing* 7, no. 3 (2019): 155-164, <http://doi.org/10.5281/zenodo.2552022>.

status in the AI race between the U.S. and China to support this thesis is timebound from 2016 to March 2022. The case studies are historical case studies bound to the 1930s to 1940s for the cryptanalysis during WWII and the race for the atomic bomb. The research for the space race is bound to the 1950s and 1960s.

Significance of the Study

While AI debuted on center stage in 1997 when IBM's system, Big Blue, defeated the world chess champion, Gary Kasparov, in a six-game match, AI did not get a standing ovation until Google DeepMind's AlphaGo system defeated the internationally top-ranked Go player, Lee Sedol, in 2016.³⁸ There are 361 possible first moves per side in Go and 10^{170} total possible board configurations, making it a googol times more complicated than Chess. A googol is translated to a "1" with a hundred zeros following. When compared to the total number of atoms in the observable universe, between 10^{78} to 10^{82} atoms, the gravity of AI's power becomes evident. This watershed moment marks the commencement of the AI race.³⁹

Today, anyone with a smartphone takes for granted the power of AI and machine learning as the applications therein are widely pervasive for navigation, human language technologies, medical applications, financial investing, and travel.⁴⁰ Breakthroughs in

³⁸ Forrest Morgan and Raphael S. Cohen, *Military Trends and the Future of Warfare: The Changing Global Environment and its Implications for the U.S. Air Force* (Santa Monica, CA: RAND Corporation, 2020), 60, https://www.rand.org/pubs/research_reports/RR2849z3.html.

³⁹ John Carl Villanueva, "How Many Atoms Are There in the Universe?" *Universe Today*, July 30, 2009, <https://www.universetoday.com/36302/atoms-in-the-universe/>.

⁴⁰ Brose, *The Kill Chain*.

Human Language Technology provide systems that can generate full text almost indistinguishable from human speech.⁴¹ Military applications for AI range from supply chain and weapon system enhancement to commander decision-making and war-gaming.⁴² Former Deputy Secretary of Defense, Robert Work, stated that AI will “change the nature of war,” realizing the next military revolution in the twenty-first century.⁴³

Conversely, the NSCAI refers to the AI revolution as a revolution of military affairs.⁴⁴ The AI revolution, which will “impact the U.S. economy, national security, and welfare, is not a strategic surprise.”⁴⁵ The NSCAI states that the U.S. “DoD should not be a witness to the AI revolution in military affairs, but should deliver it with leadership from the top, new operating concepts, relentless experimentation, and a system that rewards agility, and risk.”⁴⁶ “China possesses the might, talent, and ambition to surpass the U.S. as the world’s leader in AI in the next decade if current trends do not change.”⁴⁷ The race to break cryptographic systems, the race for the atomic bomb, and the space

⁴¹ NSCAI, *National Security Commission on Artificial Intelligence*.

⁴² Forrest E. Morgan, Benjamin Boudreaux, Andrew J. Lohn, Mark Ashby, Christian Curriden, Kelly Klima, and Derek Grossman, *Military Applications of Artificial Intelligence: Ethical Concerns in an Uncertain World* (Santa Monica, CA: RAND Corporation, 2020), <https://apps.dtic.mil/Sti/pdfs/AD1097313.pdf>.

⁴³ Bryan Walsh, “An Insider’s view of ‘Algorithmic Warfare’,” *Axios*, November 17, 2021, <https://www.axios.com/robert-work-artificial-intelligence-warfare-5d8d362b-4fc9-4b9e-aef1-4afe97ca39be.html>.

⁴⁴ NSCAI, *National Security Commission on Artificial Intelligence*, 77.

⁴⁵ *Ibid.*, 19.

⁴⁶ *Ibid.*, 77.

⁴⁷ *Ibid.*, 7.

race offer lessons to shape the national AI initiative and set conditions to gain an advantage over strategic competitors, specifically China.

Summary

The NSCAI concluded that the U.S. is not prepared to compete in the AI era, specifically for AI leadership with China.⁴⁸ In the last five years, China rapidly caught up with the U.S. in AI-related patent applications, publications, and STEM programs in higher learning institutions further lending to strategic competition between the U.S. and China to claim the leader in AI. The victor in the race for AI superiority has the potential to fundamentally change the post-World War II international order.⁴⁹ According to official U.S. Government publications and scholarly articles on the strategic competition between the U.S. and China, the race between the U.S. and China for AI leadership will largely manifest in the competition for talents.⁵⁰

The purpose of this study is to uncover the principles in talent management that may lend to supporting the U.S. in achieving a technological advantage over China in the field of AI because the greatest impediment to being AI-ready is a talent deficit. The study aims to answer the primary research question: how can the U.S. apply lessons learned pertaining to talent management from historical technological races: cryptanalysis during WWII, the race for the atomic bomb, and the space race, to maintain the competitive edge in the AI race. Former Deputy Secretary of Defense, Robert Work,

⁴⁸ NSCAI, *National Security Commission on Artificial Intelligence*, 14.

⁴⁹ You and Dingding, “Rising Sino-U.S. Competition in Artificial Intelligence,” 242.

⁵⁰ *Ibid.*, 255.

asserted that AI will change the nature of war.⁵¹ However, the U.S. DoD is not prepared for the pending AI military revolution. The race to break cryptographic systems, the race for the atomic bomb, and the space race offer lessons to shape the national AI initiative and set conditions to gain a marked advantage in information warfare over Great Power Competitors. The literature review in Chapter 2 summarizes existing publications on the status of AI in the U.S. and China and dives into historical examples of military innovations to extrapolate principles.

⁵¹ Walsh, “An Insider’s View of ‘Algorithmic Warfare’.”

CHAPTER 2

LITERATURE REVIEW

The genie was out of the bottle, and the abstract notion of Artificial Intelligence outperforming humans at complex tasks was irrevocably proven.

—Pete Tortorici, “Artificial Intelligence and Machine Learning:
Examining US and Chinese Policy Mechanisms for
Strategic Advantage in Emerging Technology”

Introduction

The literature review is designed to discover and offer a summation of existing U.S. Government and non-government publications to help answer the primary and secondary research questions. The primary research question is focused on how the U.S. can apply lessons learned pertaining to talent management from historical technological races—cryptanalysis during WWII, the race for the atomic bomb, and the space race—to maintain the competitive edge in the AI race. The secondary research questions are what talent management programs can be employed to support the U.S. in the AI race at the strategic level and how can the U.S. military overcome talent management barriers to foster the national AI strategy? The literature review is broken down into six sections: Quantitative Comparison between the U.S. and China, The PRC Approach to the AI race, The U.S. Approach to the AI race, Cryptanalysis during WWII, The Race for the Atomic Bomb, and the Space Race.

Quantitative Comparison between the U.S. and China

Since AI’s demonstrated prowess, the number of scholarly publications on AI skyrocketed. Of the most influential papers for 2020, AI papers amass citations more than

any other research topic.⁵² Further, the PRC's global share of research papers in the field of AI grew from 4.26% (1,086) in 1997 to 27.68% in 2017 (37,343), surpassing any other country in the world, including the U.S.⁵³ Figure 1 below depicts the output of AI scientific papers from China, the U.S., India, and the United Kingdom (UK) from 1997 to 2017. The graphic indicates that China far surpassed the number of publications pertaining to AI from other countries in 2017 with 37,000 publications.

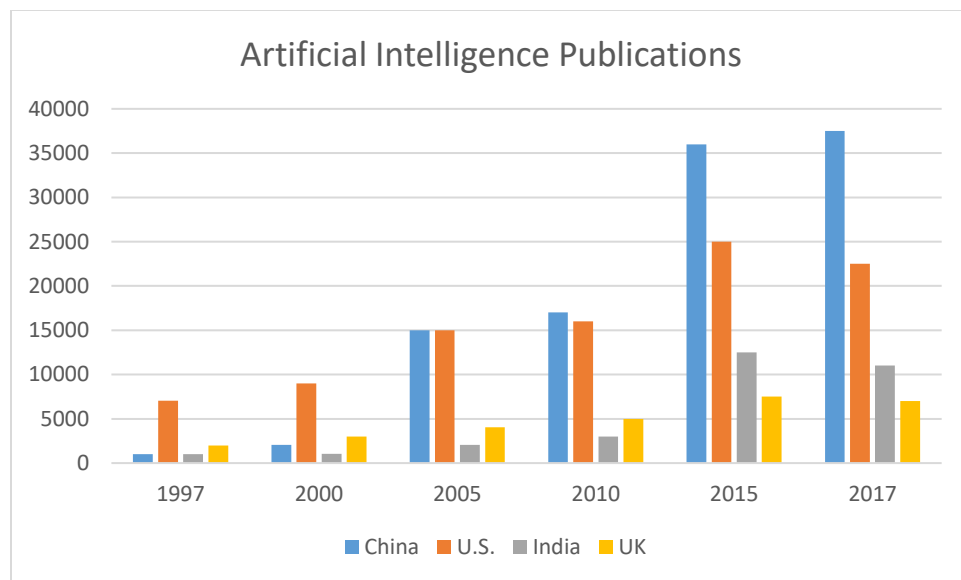


Figure 1. Global Output of AI Scientific Papers by Country until 2017

Source: Created by author using information from Daitian Li, Tony W. Tong, and Yangao Xiao, “Is China Emerging as the Global Leader in AI? *Harvard Business Review*, February 18, 2021, <https://hbr.org/2021/02/is-china-emerging-as-the-global-leader-in-ai>.

⁵² Bec Crew, “Google Scholar Reveals its Most Influential Papers for 2020,” Nature Index, July 13, 2020, <https://www.natureindex.com/news-blog/google-scholar-reveals-most-influential-papers-research-citations-twenty-twenty>.

⁵³ Daitian Li, Tony W. Tong, and Yangao Xiao, “Is China Emerging as the Global Leader in AI? *Harvard Business Review*, February 18, 2021, <https://hbr.org/2021/02/is-china-emerging-as-the-global-leader-in-ai>.

Additionally, in 2016, there were 26,891 new AI patent applications in the U.S., far surpassing China in the number of patents; however, the following year saw a stark contrast with China having four times as many AI-related patent applications.⁵⁴

To support the PRC's requirements for computer science and engineering talent, there is a push from the PRC's most senior leaders for an increase in degrees in AI-related fields in what is known as China's AI Education Strategies starting in 2017. According to "AI Education in China and the U.S.: A Comparative Assessment" by Peterson, Goode, and Gehlhaus, China is mandating AI education in its primary education system, starting in high school.⁵⁵ Specifically, the information technology curriculum encompasses python programming, AI, the Internet of Things (IoT), and big data processing.⁵⁶ Furthermore, AI companies in China are required to partner with schools and universities to train students.⁵⁷ When compared to the U.S., "only 47 percent of U.S. public high schools teach computer science in 2020, which is an increase from 35 percent in 2018."⁵⁸ At the undergraduate level, China implemented two primary mechanisms for AI training: AI institutes and standardized AI majors in Chinese universities. China's Ministry of Education approved the standardized AI curriculum for

⁵⁴ You and Dingding, "Rising Sino-U.S. Competition in Artificial Intelligence," 247.

⁵⁵ Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States: A Comparative Assessment," (CSET Issue Brief, Center for Security and Emerging Technology, Washington, DC, September 2021), 1, <https://cset.georgetown.edu/publication/ai-education-in-china-and-the-united-states/>.

⁵⁶ Ibid., 11.

⁵⁷ Ibid., 1.

⁵⁸ Ibid., 22.

up to 345 universities in early 2021.⁵⁹ Figure 2 reveals the locations of universities offering AI majors and locations of AI institutes across China.

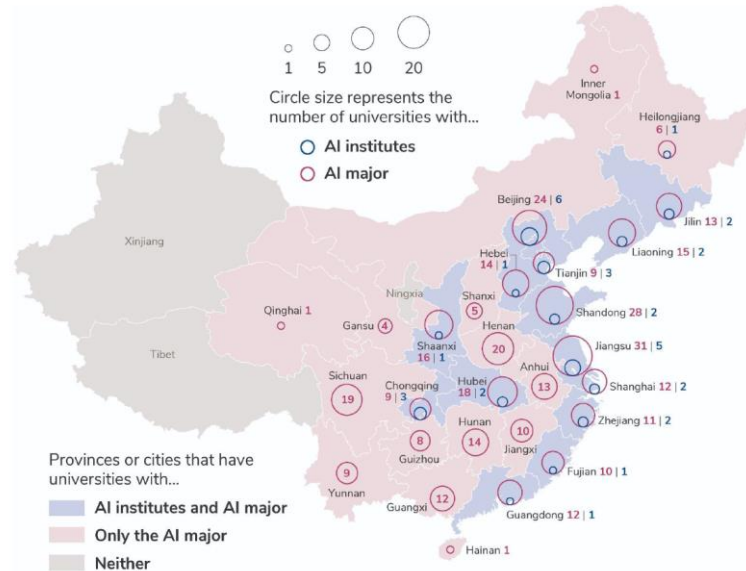


Figure 2. Locations of Universities with AI Majors and AI Institutes across China

Source: Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, “AI Education in China and the United States: A Comparative Assessment,” (CSET Issue Brief, Center for Security and Emerging Technology, Washington, DC, September 2021), 16, <https://cset.georgetown.edu/publication/ai-education-in-china-and-the-united-states/>.

The ratio in population size between China and the U.S. is 4.2:1 which is on par with the ratio in those graduating from undergraduate programs in Science, Technology, Engineering, and Math (STEM) when comparing STEM degrees by nation. Figure 3 below depicts that less than the total Chinese population attends college but of those attending, 48% graduate from a STEM program compared to 22% of those attending

14. ⁵⁹ Peterson, Goode, and Gehlhaus, “AI Education in China and the United States,”

college in the U.S. What is not depicted is that per capita, more Americans graduate from an undergraduate STEM program, per total population (.6% graduate with STEM degree compared to .3% (per total population)).

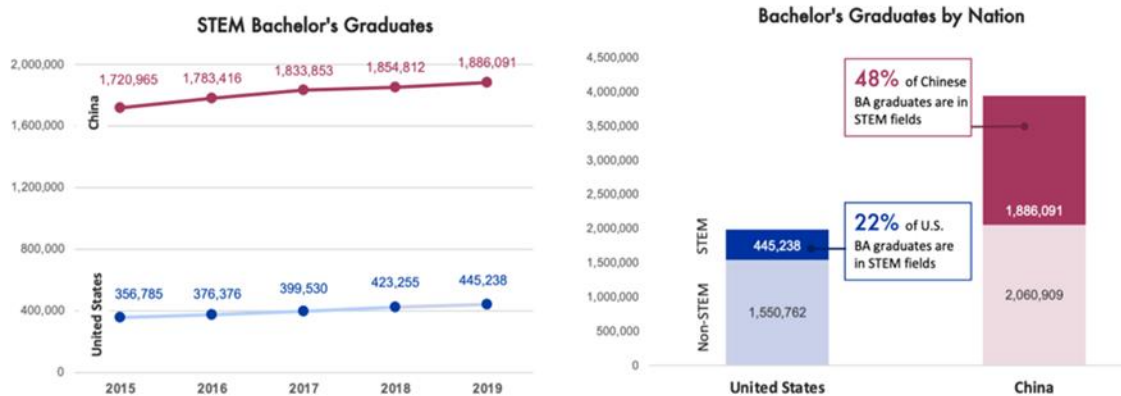


Figure 3. Comparison Chart of U.S. and China STEM Bachelor Graduates

Source: Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, “AI Education in China and the United States: A Comparative Assessment,” (CSET Issue Brief, Center for Security and Emerging Technology, Washington, DC, September 2021), 31, <https://cset.georgetown.edu/publication/ai-education-in-china-and-the-united-states>.

China has a total numerical advantage over the U.S. in STEM graduate degrees, and thus is “well-equipped to develop a robust, medium-term AI workforce pipeline.”⁶⁰ The increase in the quantity of AI-related publications, patents, and educational programs in Chinese institutions coincides with the PRC’s “New Generation Artificial Intelligence Development Plan,” which “set forth strategic aims and delineated the overarching goal

⁶⁰ Peterson, Goode, and Gehlhaus, “AI Education in China and the United States,” 34.

of making China the world leader in AI by 2030.”⁶¹ According to the National Security Commission on Artificial Intelligence (NSCAI), in only fourteen years between 2000 and 2014, China increased STEM graduate output by 360%.⁶² When compared to the U.S. during the same period, the U.S. only increased STEM output by 54%.

The PRC Approach to the AI race

Chinese Views of Big Data Analytics by Grossman, Curriden, Polley, Williams, and Cooper from the RAND Corporation, leverages Chinese primary-source materials to describe China’s big data strategy at both the China Communist Party and People’s Liberation Army (PLA) levels.⁶³ To expound on the implications of China’s National Big Data Strategy, the RAND study dissected two case studies: 1. Utilization of big data for internal population control and 2. Enhancing the PLA’s warfighting capabilities. The RAND study offered opportunities for further research, how does China’s evolving big data analytic capability rank in comparison with that of the U.S. in the military domain.⁶⁴

According to Grossman et al., primary Chinese sources indicate that China is aggressively advancing its AI-enabled big data analytics. The study’s primary source of

⁶¹ Huw Roberts, Josh Cowls, Jessica Morley, Mariarosaria Taddeo, Vincent Wang, and Luciano Floridi, “The Chinese Approach to Artificial Intelligence: An Analysis of Policy, Ethics, and Regulation,” *AI & Society* 36 (17 June 2020): 59, <https://doi.org/10.1007/s00146-020-00992-2>.

⁶² NSCAI, *National Security Commission on Artificial Intelligence*, 173.

⁶³ Derek Grossman, Christian Curriden, Logan Ma, Lindsey Polley, J. D. Williams, and Cortez A. Cooper III, *Chinese Views of Big Data Analytics* (Santa Monica, CA: RAND Corporation, 2020), https://www.rand.org/pubs/research_reports/RRA176-1.html.

⁶⁴ *Ibid.*, 48.

strategic data was Chinese President Xi Jinping's address to the 19th National Congress of the Chinese Communist Party in October 2017, during which he rallied integration of the IoT, big data, and AI initiatives to achieve great power status.⁶⁵ President Xi aims to edge China's leadership in science and technology advancements in space technology, robotics, drones, nanotechnology, molecular genetics, and solar to achieve AI-aided decision-making in government, economic, and military applications. The specific military applications include big data for command and control, intelligence, surveillance, and reconnaissance, logistics, military asset maintenance, healthcare, modeling and simulation, and cybersecurity.

According to multiple data sources, the PRC's advantage in AI stems from three critical assets in AI: vast structured data sets, the quantity of computer science and engineering talent, and the national strategy of military-civil fusion.⁶⁶ Further PRC progress in these areas to increase military competitiveness erodes U.S. national security.⁶⁷ To support the PLA's basic warfighting philosophy of active defense, the PLA utilizes a whole-of-government approach as defense-in-depth with military-civilian fusion playing a central role in achieving military objectives in peacetime and war.⁶⁸ This

⁶⁵ Grossman et al., *Chinese Views of Big Data Analytics*, vii.

⁶⁶ Grossman et al., *Chinese Views of Big Data Analytics*, vii; Anthony Cordesman, *Chinese Strategy and Military Forces in 2021: A Graphic Net Assessment* (Washington, DC: Center for Strategic and International Studies, August 3, 2021), <https://www.csis.org/analysis/updated-report-chinese-strategy-and-military-forces-2021>.

⁶⁷ Peterson, Goode, and Gehlhaus, "AI Education in China and the United States," 35.

⁶⁸ Headquarters, Department of the Army, Army Techniques Publication 7-100.3, *Chinese Tactics* (Washington, DC: Army Publishing Directorate, August 9, 2021),

concept is core to the PLA's current warfighting strategy, the "People's War," which is a modern extension of Sun Tzu's *The Art of War*. The contemporary operational concept is "People's War in Conditions of Informationization," bringing forth a new era of the digital battlefield.⁶⁹ The evolution capitalizes on cyber warfare capabilities, but in keeping pace with technological advancements in data analytics, quantum computing, AI, decentralized computing, and robotic systems, will quickly progress to Intelligentized Warfare. Figure 4 below chronicles the transformation of the People's War concept from inception to Intelligentized Warfare.

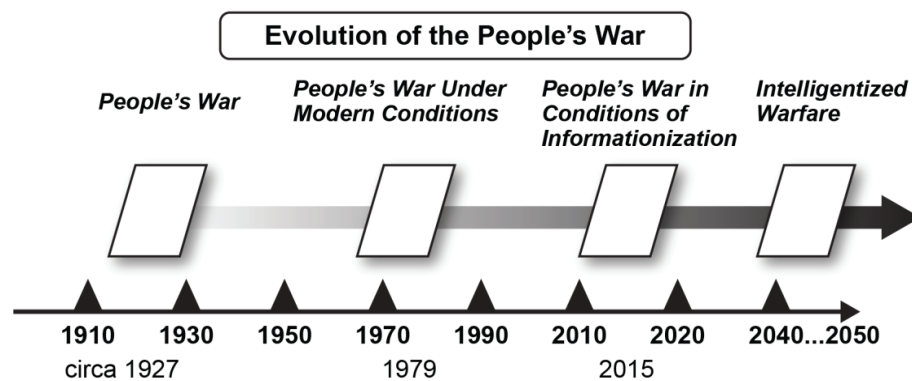


Figure 4. Transformation of the People's War Concept to Intelligentized Warfare

Source: Headquarters, Department of the Army, Army Techniques Publication 7-100.3, *Chinese Tactics* (Washington, DC: Army Publishing Directorate, August 9, 2021), 1-9, https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN33195-ATP_7-100.3-000-WEB-1.pdf.

https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN33195-ATP_7-100.3-000-WEB-1.pdf.

⁶⁹ Ibid.

To transform the PLA along the Evolution of People's War continuum, the PRC issued policies to attract international AI talents from universities and research institutions in developed countries.⁷⁰

According to the Office of the Secretary of Defense's annual report to Congress titled *Military and Security Developments Involving the PRC 2021*, the PRC seeks to become a world leader in Fourth Industrial Revolution technologies, which are ones that blur the lines between the physical, digital, and biological spheres.⁷¹ These technologies include smart sensors, AI, 3D printing, IoT platforms, wearable electronics, quantum information sciences, autonomous systems, and advanced material manufacturing.⁷² Through the PRC's military-civilian fusion, the PLA is accelerating its modernization efforts to become "a 'world-class' military capable of 'intelligentized' warfare."⁷³ In pursuant to the People's War concept of Intelligentized Warfare, the PLA is delving into next-generation operational concepts to include attrition warfare by intelligent swarms,

⁷⁰ You and Dingding, "Rising Sino-U.S. Competition in Artificial Intelligence," 256.

⁷¹ Office of Secretary of Defense (SecDef), *Military and Security Developments Involving the People's Republic of China 2021: A Report to Congress*, Pursuant to the National Defense Authorization Act for Fiscal Year, 2000 (Washington, DC: Department of Defense, 2021), 145, <https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF>; Klaus Schwab, "The Fourth Industrial Revolution: What it Means, How to Respond," World Economic Forum, January 14, 2016, <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/>.

⁷² SecDef, *Military and Security Developments Involving the People's Republic of China 2021*, 145.

⁷³ Ibid.

cross-domain mobile warfare, AI-based space confrontation, and cognitive control operations.⁷⁴ The PRC focuses AI efforts to achieve its long-term strategy.

In summary, the PRC's AI strategy nests within and advances the military strategy of Intelligentized Warfare, both of which are top-down driven by the president, Xi Jinping. Since President Xi's address in 2017, which was in quick succession after AI's dominance in Go, the number of publications, patents, and people in AI-related fields rose steeply. The centralized control nature of AI development under the PRC's Next Generation AI Plan is in stark contrast to the U.S. approach to the AI race.⁷⁵

The U.S. Approach to the AI Race

Military applications of AI could significantly change the character of war, as significantly as the French Revolution, within the next fifteen years.⁷⁶ Forrest Morgan and Raphael Cohen published a RAND Corporation study titled *Trends and the Future of Warfare: The Changing Global Environment and its Implications for the U.S. Air Force* in *The Future of Warfare* journal which chronicles the advancement of AI over the last fifteen years.⁷⁷ Progress in AI includes the development of big data analysis, autonomous weapons, robotics, and decision-enabling systems using neural network technologies. The current and future military applications of AI are boundless. Recent emerging AI

⁷⁴ SecDef, *Military and Security Developments Involving the People's Republic of China 2021*, 145.

⁷⁵ You and Dingding, "Rising Sino-U.S. Competition in Artificial Intelligence," 250.

⁷⁶ Morgan and Cohen, *Military Trends and the Future of Warfare*, 59.

⁷⁷ Ibid.

capabilities include remotely piloted vehicles and robotic swarming, copious numbers of autonomous vehicles or weapons programmed with rules that, when applied to the entire group, exhibit emergent behavior that makes them much more effective in combat than would be possible by the same number of devices under human control.⁷⁸

According to Morgan and Cohen, there is a panoply of AI applications just beyond the near horizon including autonomous weapons and intelligence, surveillance, and reconnaissance assets, but arguably the most relevant application is the usage of AI to allow warfighters to bring big data to bear to analyze vast volumes of information that would be impossible for humans to process. Pattern recognition at scale will offer the opportunity for intelligence analysts to identify enemy tactics and hidden or obscure targets, improve accuracy, and support command decision-making with reliability.⁷⁹

Chuck Hagel, former Secretary of Defense, and Christian Brose, previous staff director of the Senate Armed Services Committee under Chairman John McCain, advocate for the U.S. to develop military applications of AI to regain a qualitative advantage over strategic competitors.⁸⁰ The U.S. does not have a monopoly on AI-enabled big data analytics in the same way it did for precision-guided munitions, stealth technology, and command, control, communications, computer, intelligence, surveillance, reconnaissance (C4ISR) in the 1980s.⁸¹ AI, machine learning, and neural network technologies are currently being developed in academic and commercial

⁷⁸ Morgan and Cohen, *Military Trends and the Future of Warfare*, 61.

⁷⁹ Ibid., 62.

⁸⁰ Ibid., 64.

⁸¹ Ibid.

sectors.⁸² China's PLA is aggressively advancing air and ground autonomous vehicles and automated systems for C4ISR.

In *The Kill Chain*, Christian Brose argues that the power competitor with the fastest, most effective kill chain, or the ability to understand threats, make decisions, and take military actions, will win future wars. Brose poignantly criticizes the U.S. bureaucratic, budget, and acquisition processes that hinder the ability to invest in AI and emerging technologies to transform the U.S. military in the current technological revolution and seek an advantage over its nearest competitors, China, and Russia.⁸³ According to Brose, the U.S. military is a bureaucracy, failing to promote innovative technological solutions to close the information warfare gap.

Using the DoD's AI definition as "the ability of machines to perform tasks that normally require human intelligence," one can extrapolate requirements to satisfy AI development and utilization across the military enterprise.⁸⁴ In *Strategic Competition in an Era of Artificial Intelligence* by Michael Horowitz et al., six national power elements are identified to secure AI as a U.S. strategic means:

Large quantities of the right data type depending on the desired application;

Recruit, train, retain and equip highly technical, AI-capable programmers by providing PhD-level training and compensation;

Computing resources to train machines;

⁸² Morgan and Cohen, *Military Trends and the Future of Warfare*, 64.

⁸³ Brose, *The Kill Chain*.

⁸⁴ DoD, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*, 5.

Incentivize DoD organizations to use AI capabilities and educate commanders on its effectiveness to meet the commander's vision; and,

Increased public-private cooperation by tapping into the innovative capacity of private companies to harness AI capabilities across the services.⁸⁵

Joint warfighters at all echelons need access to reliable, available, and secure data to conduct the core missions of each service in an integrated ecosystem. "Survival on the modern battlefield will depend upon leveraging and making connections among data from diverse sources, using analytic tools for superior situational awareness, and coordinating information for disaggregated-precision effects."⁸⁶ The DoD must accelerate change to become a data-centric organization or lose to international competitors who are able to achieve the asymmetric digital advantage.⁸⁷ The *DoD Data Strategy* identifies its decisive problem as the inability to provide battlespace commanders, warfighters, decision-makers, and mission partners access to timely, relevant, and secure data to make decisions and execute actions to safeguard U.S. national interests.⁸⁸

President Donald Trump signed Executive Order 13859, titled *American AI Initiative*, in February 2019, which was codified into law as part of the National AI Initiative Act of 2020.⁸⁹ The National AI Initiative's mission is to safeguard "U.S.

⁸⁵ Horowitz et al., *Strategic Competition in an Era of Artificial Intelligence*, 5-6.

⁸⁶ Deputy Secretary of Defense, *DoD Strategy: Unleashing Data to Advance the National Defense Strategy* (Washington, DC: Department of Defense, September 30, 2020), 1, <https://media.defense.gov/2020/Oct/08/2002514180/-1/-1/0/DOD-DATA-STRATEGY.PDF1>.

⁸⁷ Ibid.

⁸⁸ Ibid.

⁸⁹ U.S. President, Executive Order 13859.

leadership in AI research and development, lead the world in the development and use of trustworthy AI in the public and private sectors, maximize the benefits of AI systems for all American people, and prepare the present and future U.S. workforce for the integration of AI systems across all sectors of the economy and society.”⁹⁰ The Act created the National AI Initiative Office to oversee the implementation of the U.S. national AI strategy and its five lines of effort, including increasing AI research investment, unleashing Federal AI computing and data resources, setting AI technical standards, building America’s AI workforce, and engaging with international allies.⁹¹ The Act’s AI for the American Worker Line of Effort provides a vision to bolster the AI-skilled American worker.⁹² Nation-wide initiatives include apprenticeships, American STEM education, research and development training, and vocational training.⁹³

In December 2018, the National Science and Technology Council’s Committee on STEM Education (CoSTEM) released the Federal 5-Year STEM Education Strategic Plan, which outlines the goals for American STEM education.⁹⁴ In a report titled

⁹⁰ National Artificial Intelligence Office, *National Artificial Intelligence Initiative: Overseeing and Implementing the United States National AI Strategy* (Washington, DC: The White House Office of Science and Technology Policy, April 15, 2022), <https://www.ai.gov/>.

⁹¹ Ibid.

⁹² U.S. President, Executive Order 13859.

⁹³ Ibid.

⁹⁴ National Science and Technology Council (NSTC), Committee on STEM Education. *Charting a Course for Success: America’s Strategy for STEM Education* (Washington, DC: Executive Office of the President of the United States, December 1, 2018), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf>.

Charting a Course for Success: America's Strategy for STEM Education, the CoSTEM provided a roadmap to “develop STEM literacy, increase diversity, equity, and inclusion in STEM, and develop the future STEM workforce.”⁹⁵ According to the CoSTEM report, “basic STEM concepts are best learned at an early age—in elementary and secondary school—because they are the essential prerequisites” for a lifetime in the workplace.⁹⁶ Not all Americans are interested in pursuing employment in a STEM-related field. “Even for those who may never be employed in a STEM-related job, a basic understanding and comfort with STEM and STEM-enabled technology have become a prerequisite for full participation in modern society.”⁹⁷

The lead U.S. DoD organization to realize the American AI Initiative Act and DoD's AI Strategy is the Joint Artificial Intelligence Center (JAIC).⁹⁸ The JAIC provides AI capability delivery projects focused on problems that cross military services or departments. These projects are called National Mission Initiatives. The JAIC also provides AI project support, Component Mission Initiatives, to one DoD Component or agency. The JAIC's goals are nested in the five pillars of the DoD AI Strategy:

Deliver AI-enabled capabilities that address key missions,

Scale AI's impact across DoD through a common foundation that enables decentralized development and experimentation,

Cultivate a leading AI workforce,

⁹⁵ NSTC, *Charting a Course for Success*, v.

⁹⁶ *Ibid.*

⁹⁷ *Ibid.*, 5.

⁹⁸ “About: Joint Artificial Intelligence Center,” Joint Artificial Intelligence Center (JAIC), accessed March 16, 2022, <https://www.ai.mil/about.html>.

Engage with commercial, academic, and international allies and partners, and,

Lead in military ethics and AI safety.⁹⁹

Pursuant to these DoD AI Strategy goals, the JAIC conducted five International Dialogues for AI in Defense symposiums and delivered several AI capabilities to U.S. Special Operations Command and DoD Services. In early 2022, the JAIC “launched new AI education pilots for thousands of DoD employees that range from executive education for general officers to in-depth coding boot camps.”¹⁰⁰ The current pilot project is in partnership with the Massachusetts Institute of Technology; however, the goal is to scale a range of AI training, from AI 101 to coding boot camps, for all of DoD’s approximately three million employees and service members.¹⁰¹ “These initiatives stem from a congressional mandate for the JAIC to develop an AI workforce and education strategy in the fiscal 2020 National Defense Authorization Act.”¹⁰²

The U.S. Deputy Secretary of Defense signed a memorandum titled “Initial Operating Capability of the Chief Digital and Artificial Intelligence Officer” on February 1, 2022.¹⁰³ In the memorandum, the Deputy Secretary of Defense outlines the functions

⁹⁹ “About: Joint Artificial Intelligence Center,” JAIC.

¹⁰⁰ Jackson Barnett, “JAIC Piloting Artificial Intelligence Education for DoD,” *Fedscoop*, February 14, 2022, <https://www.fedscoop.com/jaic-piloting-artificial-intelligence-education-for-dod/>.

¹⁰¹ *Ibid.*

¹⁰² *Ibid.*

¹⁰³ Deputy Secretary of Defense, Memorandum, Subject: Initial Operating Capability of the Chief Digital and Artificial Intelligence Officer (Department of Defense, Washington, DC, February 1, 2022), <https://media.defense.gov/2022/Feb/02/2002931807/-1/-1/1/MEMORANDUM-ON-THE-INITIAL-OPERATING->

of the Chief Digital and Artificial Intelligence Officer (CDAO) and its support office. The CDAO is chartered to lead and oversee DoD's strategy development and policy formulation for data, analytics, and AI; break down barriers to data and AI adoption within appropriate DoD institutional processes; and, create enabling digital infrastructure and services that support each DoD service's development of data, analytics, AI and digital-enabled solutions.¹⁰⁴ The signed memorandum states that the CDAO will have the authority, direction, and command and control over resources and personnel to accomplish the aforementioned assigned tasks. The authorities granted to the CDAO include acquisition, talent management support, and access to all DoD data.¹⁰⁵

A RAND Corporation study in 2019 revealed shortfalls to the DoD's AI strategy. The *Department of Defense Posture for Artificial Intelligence: Assessment and Recommendations* by Tarraf et al. from RAND Corporation conducted an AI posture assessment based on six dimensions that formed an analytical framework: Organization, Advancement, Adoption, Innovation, Data, and Talent.¹⁰⁶ The most critical point highlighted in the RAND study was that while the DoD established the JAIC to execute

CAPABILITY-OF-THE-CHIEF-DIGITAL-AND-ARTIFICIAL-INTELLIGENCE-OFFICER.PDF.

¹⁰⁴ Ibid.

¹⁰⁵ Ibid.

¹⁰⁶ Danielle C. Taraf, William Shelton, Edward Parker, Brien Alkire, Diana Gehlhaus, Justin Grana, Alexis Levedahl, Jasmin Leveille, Jared Mondschein, James Ryseff, Ali Wyne, Daniel Elinoff, Edward Geist, Benjamin N. Harris, Eric Hui, Cedric Kenney, Sydne Newberry, Chandler Sachs, Peter Schirmer, Danielle Schlang, Victoria M. Smith, Abbie Tingstad, Padmaja Vedula, and Kristin Warren, *Defense Posture for Artificial Intelligence: Assessment and Recommendations* (Santa Monica, CA: RAND Corporation, 2019), https://www.rand.org/pubs/research_reports/RR4229.html.

the DoD’s ambitious vision for its AI strategy, the DoD “failed to provide the JAIC with visibility, authorities, and resource commitments, making it exceedingly difficult for the JAIC to succeed in its assigned mandate.”¹⁰⁷ Furthermore, due to a lack of baselines and metrics, there is no feasible mechanism to assess the JAIC’s progress in achieving the DoD’s AI strategy.¹⁰⁸ The strategic and tactical recommendations for the sixth dimension of the RAND study’s analytical framework, Talent, is based on synthesized interview responses from several entities across the DoD, academia, and industry.

RAND study interview responses suggested that there is no defined consensus on AI knowledge, competencies, and expertise required for the DoD talent pools. The DoD-specific interviews highlighted three primary issues that are subsequently echoed in the NSCAI which are “intense competition with the private sector, limited ability to compete on salary, and long hiring processes.”¹⁰⁹ However, the DoD may overcome these limitations by aligning talent to projects that solve interesting problems of national importance. Furthermore, those interviewed within the DoD suggest that increasing digital literacy across the Services may, in turn, cultivate the respect and promotion of members with technical competence. Table 1 provides a summation of recommendations based on study interviews, per entity (e.g., DoD, academia, and industry), to cultivate AI talent pools for the DoD.

¹⁰⁷ Taraf et al., *Defense Posture for Artificial Intelligence: Assessment and Recommendations*, xiii.

¹⁰⁸ Ibid.

¹⁰⁹ Ibid., 62-63.

Table 1. RAND Study Summary of DoD, Academia, and Industry Interviews		
DoD	Academia	Industry
Emphasize mission	Emphasize mission	Emphasize mission
Promote challenging technical problems	Promote challenging technical problems	Promote challenging technical problems
Offer flexibility among the active, reserve, and civilian components	Attract partnerships through releasing interesting data sets	Attract partnerships through releasing interesting data sets
Cultivate respect of and promotion for members with technical competence	Offer flexible care paths (e.g., ability to move between roles)	Emphasize personal connections and networks
Host competitions and sponsoring postdoctoral fellowships	Provide retention incentives	Establish university pipelines to organization
Increase management awareness of AI and its abilities		Offer continuous training in computer science and coding courses

Source: Created by author using information from Danielle C. Taraf, William Shelton, Edward Parker, Brien Alkire, Diana Gehlhaus, Justin Grana, Alexis Levedahl, Jasmin Leveille, Jared Mondschein, James Ryseff, Ali Wyne, Daniel Elinoff, Edward Geist, Benjamin N. Harris, Eric Hui, Cedric Kenney, Sydne Newberry, Chandler Sachs, Peter Schirmer, Danielle Schlang, Victoria M. Smith, Abbie Tingstad, Padmaja Vedula, and Kristin Warren, *Defense Posture for Artificial Intelligence: Assessment and Recommendations* (Santa Monica, CA: RAND Corporation, 2019), https://www.rand.org/pubs/research_reports/RR4229.html.

Commonalities in interview responses for the three entities included recommendations for the DoD to emphasize its nationally important mission, hard technical challenges, and flexible career paths to attract people with AI expertise but from there, responses diverged with academia and industry focusing on data sets partnerships and training.

The National Defense Authorization Act for Fiscal Year 2019 formed and instructed the NSCAI to examine the current AI operational environment and offer recommendations on how the U.S. can create a competitive advantage. The result was that the U.S. is not ready to compete in the AI era; therefore, the commission called for a

whole-of-nation approach to accelerate action to compete “for the sake of U.S. prosperity, security, and welfare.”¹¹⁰ The 756-page report parses findings into two parts:

1. Defending America in the AI era, and 2. Winning the technology competition.

According to the NSCAI, challenges to recruiting and retaining AI-related talent in the U.S. Government are due to the inability of the government to compete with private-sector salaries, the cumbersome hiring process, the slow security clearance process, and what many STEM degree graduates perceive as not meaningful work.¹¹¹ In 2020, there were over 430,000 computer science positions in the U.S. but only 71,000 new computer science graduates from U.S. universities.¹¹² The NSCAI offered several recommendations to counter these issues and to organize, recruit, build and employ a digital workforce to advance AI across the U.S. Government. These recommendations will be compared to tenets garnered from the case studies in Chapters 4 and 5.

In summary, when compared to the PRC’s centralized, top-down approach to AI advancement, the U.S. is decentralized and not coherent in its approach. The democratized nature of the U.S. strategy offers flexibility; however, it may also lend to a lack of urgency to adapt to technological advancements afforded by AI. Several ranking members in the U.S. Government are advocating for rapid change to meet the demands of today, not yesterday. The greatest criticisms have been about the U.S. military’s slow and antiquated force management requirements and acquisition processes. There are lessons

¹¹⁰ NSCAI, *National Security Commission on Artificial Intelligence*, 1.

¹¹¹ *Ibid.*, 124.

¹¹² *Ibid.*, 126.

to be gleaned from technological breakthroughs of the past that led to achieving a marked advance in a race with a peer competitor.

Cryptanalysis during WWII

During World War II, men deployed to the European and Pacific theaters leaving a shortage in the STEM workforce in the rear. The U.S. and UK systematically recruited tens of thousands of women, under Women Accepted for Volunteer Emergency Service (WAVES), to be the first cryptanalysts for the government in the District of Columbia and Bletchley Park respectively. In the U.S., the women were recruited and tested for aptitude in clerical, technical, or analytical work roles that were not glamorous, but rather tedious and mentally daunting.¹¹³ The work was a top-secret process to crack German and Japanese cryptographic methods. For many, this was the first-time women were paid for work or had their voices heard.

In the U.S., the government recruited women from women's colleges and from teaching positions across the country. Women, identified as having a high math and science aptitude, received a letter from the U.S. Government and asked two questions: do you like crossword puzzles, and are you engaged to be married? The U.S. Navy created a recruiting campaign and a secret cryptanalysis class for the newly recruited women. In the UK, upon arrival at Bletchley Park's Government Code and Cypher School, women went to Hollerith school where they spent six weeks learning how to adapt Hollerith

¹¹³ Mundy, *Code Girls*.

accounting machines into cryptographic machines.¹¹⁴ Along with cryptanalysts and AI pioneer, Alan Turing, the women took intercepted messages from Japanese aircraft and German naval vessels and then deciphered the messages to discover the enemy's order of battle, locations, disposition, and strategic direction. "The decoding of one message led to the location of the Scharnhorst, one of Germany's most famous battleships, being revealed."¹¹⁵ Allied forces gained a decisive advantage, conducted a direct attack, and defeated the ship in the Battle of the North Cape, off Norway.

Liza Mundy collected archival documents from U.S. Army and U.S. Navy code-breaking units, and the National Security Agency, most of which were classified for decades, to research and document the stories of the women cryptanalysts during the war.¹¹⁶ In her book, *Code Girls*, Liza Mundy details the mass recruitment of women from across the U.S. with expertise in the field of mathematics, science, foreign languages, and possessing "character, loyalty, and grit."¹¹⁷ In all, the U.S. Government recruited tens of thousands of women as part of a campaign to invest more heavily in codebreaking to offset the U.S.' lag in comparison with other nations in its cryptology studies in WWII.

¹¹⁴ Suzanne Bearne, "Meet the Female Codebreakers of Bletchley Park," *The Guardian*, July 24, 2018, <https://www.theguardian.com/careers/2018/jul/24/meet-the-female-codebreakers-of-bletchley-park>.

¹¹⁵ Ibid.

¹¹⁶ Mundy, *Code Girls*, xiii.

¹¹⁷ Ibid., 14.



Figure 5. Women Cryptanalysts Working at Arlington Hall in Washington, DC

Source: Jennifer Wilcox, *Sharing the Burden: Women in Cryptology during World War II* (Fort George G. Meade, MD: Center for Cryptologic History, National Security Agency, 1998), cover, https://www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/sharing_the_burden.pdf.

The contributions of the cryptanalysts to the Allied victory cannot be measured.¹¹⁸ After discovering patterns in Japanese message traffic, the cryptanalysts built a “Purple” analog machine to decode Japanese diplomatic messages.¹¹⁹ On April 13, 1943, the cryptanalysts deciphered a message titled “Solomons Defense Force, Air Group 204, AirFlot 26, Commander Ballale Garrison Force.”¹²⁰ The message suggested that Admiral Yamamoto, the Japanese commander who orchestrated the attack on Pearl Harbor, was

¹¹⁸ Wilcox, *Sharing the Burden*.

¹¹⁹ *Ibid.*, 1.

¹²⁰ Mundy, *Code Girls*, 200.

headed to Ballale Island on April 18, 1943.¹²¹ Piecing together fragmented messages provided a complete travel itinerary for Admiral Yamamoto. U.S. naval Admiral Nimitz decided to use the deciphered itinerary to devise a plan to target the Japanese Admiral, called Operation Vengeance.¹²² On April 18, sixteen U.S. Army P-38s took off from Guadalcanal airfield for Bougainville where the fighters came into contact with Japanese fighters and two bombers. After U.S. forces shot down the Japanese bombers, “Yamamoto’s body was found in the Bougainville jungle, his white-gloved hand clutching his sword.”¹²³ The orchestrator of the “Day of Infamy” was dead.¹²⁴

The U.S. cryptanalysts were in constant contact with their British counterparts to collaborate on breaking the German codes. Alan Turing designed the Bombe machine to crack the German Enigma code that the Germans perceived to be unbreakable. Winston Churchill and President Eisenhower credited Alan Turing and the women cryptanalysts in both the U.S. and UK with shortening the war by two years due to their ability to intercept, decipher, understand, and convey the enemy’s campaign, disposition of U-boats, Panzer divisions, Luftwaffe targets and the High Command itself.¹²⁵

¹²¹ Mundy, *Code Girls*, 200.

¹²² *Ibid.*

¹²³ *Ibid.*, 201.

¹²⁴ *Ibid.*

¹²⁵ Sinclair McKay, *The Secret Lives of Codebreakers: The Men and Women Who Cracked the Enigma Code at Bletchley Park* (New York: Penguin Group, 2010).

The Race for the Atomic Bomb

In July 1939, concerned scientists, Leo Szilard, Eugene Wigner, and Edward Teller, drafted a letter, signed by Albert Einstein, to President Roosevelt to inform him of the potential of nuclear fission and concerns over Germany's development of an atomic bomb.¹²⁶ In reaction, President Roosevelt set up the Advisory Committee on Uranium that tasked a team of scientists and military officials with researching uranium's potential role as a weapon.¹²⁷ After delivering a proof of concept, the U.S. Government began funding research on uranium enrichment and nuclear chain reactions.¹²⁸ In 1940, President Roosevelt "transferred the Uranium Committee to the newly-created National Defense Research Committee."¹²⁹ Additionally, U.S. and UK formalized bilateral cooperation to further the development of the atomic bomb.

Physicists Enrico Fermi and Leo Szilard researched nuclear chain reactions, the process by which atoms separate and interact, at the University of Chicago.¹³⁰ Scientists at the time were conducting research in a distributed network across the country, lacking a unified direction. On December 28, 1942, President Roosevelt authorized a single

¹²⁶ Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 2012).

¹²⁷ History.com Editors, "Manhattan Project," History, January 17, 2020, <https://www.history.com/topics/world-war-ii/the-manhattan-project>.

¹²⁸ Ibid.

¹²⁹ U.S. Department of Energy, Office of History and Heritage Resources, "Early Uranium Research," The Manhattan Project: An Interactive History, accessed April 17, 2022, https://www.osti.gov/opennet/manhattan-project-history/Events/1939-1942/uranium_research.htm

¹³⁰ History.com Editors, "Manhattan Project."

project to combine these various research efforts with the goal of weaponizing nuclear energy.¹³¹ Brigadier General Leslie Groves, head of the Army Corps of Engineers, commenced the Manhattan Project, the U.S. Government research project that produced the first atomic bombs.¹³²

General Groves, a decisive leader, identified theoretical physicist, J. Robert Oppenheimer, to lead the creation, test, and evaluation of atomic bombs at the Los Alamos Laboratory in northern New Mexico beginning in 1943.¹³³ The Voices of the Manhattan Project, in partnership with the National Museum of Nuclear Science and History, was an endeavor to conduct interviews with the scientists who worked on the Manhattan Project. In an interview with Stephane Groueff in 1965, J. Robert Oppenheimer detailed being on recruiting trips at universities when he confirmed his appointment as the lead of the new nuclear bomb site in New Mexico. He was personally recruiting scientists for the project.¹³⁴ In Groueff's interview with General Groves in January 1965, General Groves indicated that the sense of urgency was so great to field the atomic bomb that there was no time for perfection. Specifically, he stated, "You could

¹³¹ History.com Editors, "Manhattan Project."

¹³² The Editors of Encyclopedia Britannica, "The Manhattan Project," Britannica, March 8, 2022, <https://www.britannica.com/event/Manhattan-Project>.

¹³³ History.com Editors, "Manhattan Project."

¹³⁴ J. Robert Oppenheimer, interview by Stephane Groueff, Voices of the Manhattan Project, 1965, <https://www.manhattanprojectvoices.org/oral-histories/j-robert-oppenheimers-interview>.

not achieve perfection. That is one of the things that made people think that I rode roughshod over them.”¹³⁵

Under a centralized leader, General Groves, scientists at remote sites in Tennessee, Washington state, and New Mexico collaborated on the concept of nuclear fission.¹³⁶ At Oak Ridge National Laboratory near Knoxville, Tennessee, the U.S. built a reactor to produce uranium-235 and plutonium. In Hanford, Washington, the U.S. built the world’s first large-scale plutonium reactor.¹³⁷ Scientists sent enriched plutonium from Hanford to the scientific for final construction at Los Alamos.¹³⁸ Figure 6 below depicts the Manhattan Project organizational chart, which represents the central chain of command to the president but a flat organization for the services and project sites.

¹³⁵ Leslie Groves, interview by Stephane Groueff, *Voices of the Manhattan Project*, January 5, 1965, <https://www.manhattanprojectvoices.org/oral-histories/general-leslie-groves-interview-part-1>.

¹³⁶ History.com Editors, “Manhattan Project.”

¹³⁷ History.com Editors, “The Trinity Test,” *History*, August 21, 2018, <https://www.history.com/topics/world-war-ii/trinity-test>.

¹³⁸ *Ibid.*

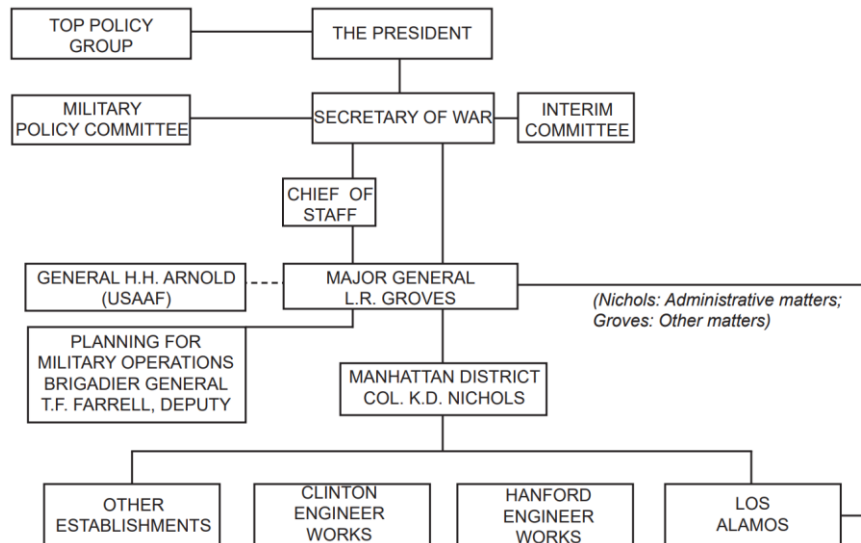


Figure 6. Manhattan Project Organization Chart

Source: Francis George Gosling, *The Manhattan Project: Making the Atomic Bomb* (Collingdale, PA: Diane Publishing, 1999), 103.

At 5:30 a.m. on July 16, 1945, Los Alamos scientists detonated a plutonium bomb at the Trinity Test Site.¹³⁹ Scientists at Los Alamos Laboratory in New Mexico “developed two distinct types of bombs: a uranium-based design called ‘the Little Boy’ and a plutonium-based weapon called ‘the Fat Man.’”¹⁴⁰ Little Boy and Fat Man were perceived to be crucial to the U.S. strategy aimed at bringing an end to World War II.¹⁴¹ On August 6, 1945, the U.S. dropped Little Boy in the city center of Hiroshima, Japan, followed by Fat Man on August 9, 1945, in Nagasaki. Following the dropping of the

¹³⁹ History.com Editors, “The Trinity Test.”

¹⁴⁰ History.com Editors, “Manhattan Project.”

¹⁴¹ Ibid.

atomic bombs, Japanese Emperor Hirohito surrendered via radio broadcast on August 15, 1945, bringing an end to WWII.¹⁴²

The Space Race

In a speech at Rice University on September 12, 1962, President John F. Kennedy stated,

We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too.¹⁴³

The Cold War space competition between the U.S. and the Union of Soviet Socialist Republics (USSR), which centered on the race to the moon, offers both an exceptionally revealing historical case and larger implications for space and technology development.”¹⁴⁴ The USSR launched Sputnik 1 (Russian for “traveler”) into space on October 4, 1957, catapulting the world into the Space Age, and with it the space race between the U.S. and the USSR.¹⁴⁵ Before the U.S. could gain traction in the space race,

¹⁴² History.com Editors, “Bombing of Hiroshima and Nagasaki,” History, April 26, 2021, <https://www.history.com/topics/world-war-ii/bombing-of-hiroshima-and-nagasaki>.

¹⁴³ John F. Kennedy, “Moon Speech at Rice University (As Delivered),” Transcript, September 12, 1962, <https://er.jsc.nasa.gov/seh/ricetalk.htm>.

¹⁴⁴ Andrew S. Erickson, “The Space Race Revisited: The Lunar Landing and Its Larger Lessons,” in *Proceedings of the Fifty-first History Symposium of the International Academy of Astronautics*, American Astronautical Society (AAS) History Series, vol. 50, ed. Michael L. Ciancone (San Diego, CA: Univelt, 2020), 289-342, <https://www.andrewerickson.com/2020/08/the-space-race-revisited-the-lunar-landing-and-its-larger-lessons/>.

¹⁴⁵ History.com Editors, “The Space Race,” History, February 21, 2020, <https://www.history.com/topics/cold-war/space-race>.

the Soviet Union's cosmonaut Yuri Gagarin became the first person to journey into space and orbit Earth in April 1961. In May 1961, astronaut Alan Shepard became the first U.S. citizen and the second person to go to space.¹⁴⁶ By all accounts, the U.S. was losing the space race to which the U.S. President set forth a national agenda in space exploration.¹⁴⁷

The Soviet Union trailblazed space exploration with Sergei Pavlovich Korolev, regarded by many as the father of practical astronautics, as lead rocket engineer and spacecraft designer during the space race between the U.S. and the Soviet Union. The U.S. solicited German-American engineer Dr. Wernher von Braun, former chief engineer of the Nazi V-2 program, to direct NASA's Marshall Space Flight Center where he and his team began the development of the Saturn V super-heavy lift launch vehicle.¹⁴⁸ Hundreds of skilled engineers, machinists, and fabricators from across the country spent thousands of hours developing each component of the Saturn V before the components were assembled at the Kennedy Space Center in Florida.¹⁴⁹

With a five hundred percent increase in budget, the newly minted National Aeronautics and Space Administration (NASA) employed thirty-four thousand direct employees and three hundred seventy-five thousand industrial and university contractors to propel its lunar landing program. In December 1968, NASA launched Apollo 8, the

¹⁴⁶ Loyal Liverpool, "Katherine Johnson," *NewScientist*, December 15, 2021, <https://www.newscientist.com/people/katherine-johnson/>.

¹⁴⁷ Graham Duggins, "The Space Age: A Lookback at American Ingenuity," *Cincinnati Republic*, July 29, 2019, <http://www.cincinnati-republic.com/the-space-age-a-lookback-at-american-ingenuity/>.

¹⁴⁸ Ibid.

¹⁴⁹ Ibid.

first manned space mission to orbit the moon.¹⁵⁰ In July 1959, NASA launched Apollo 11, and U.S. astronauts Neil Armstrong, Edwin “Buzz” Aldrin, and Michael Collins to land on the moon. Upon Armstrong’s famous words, “one small step for man, one giant leap for mankind” from the surface of the moon, the space race was effectively over.¹⁵¹

In 1958, the U.S. federal government, realizing the deficit in talented STEM students to keep pace with the country’s strategic vision, passed the National Defense Education Act (NDEA), which stimulated the advancement of education in STEM and foreign languages.¹⁵² “The law provided federal funding to ‘insure trained manpower of sufficient quality and quantity to meet the national defense needs of the U.S.’.”¹⁵³ According to James Brahm’s “STEM Education Should be a National Security Priority” in the *Space Force Journal*, due to Spacepower being an inherently technological instrument of politics and the fact that a state’s ability to exert influence in the space domain is linked to its technical-informational base, scientific and technological education fortifies national defense requirements.¹⁵⁴ Technological education increases

¹⁵⁰ History.com Editors, “The Space Race.”

¹⁵¹ Ibid.

¹⁵² Linda J. Sheffield, “Mathematically Promising Students from the Space Age to the Information Age,” *The Mathematics Enthusiast* 3, no. 1, (2006): 104-109, <https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=1039&context=tme>.

¹⁵³ National Defense Education Act. H. Res. 13247, 85th Cong., (August 21, 1958), <https://history.house.gov/HouseRecord/Detail/15032436195>.

¹⁵⁴ James Brahm, “STEM Education Should be a National Security Priority,” *The Space Force Journal*, no. 1 (January 31, 2021), <https://spaceforcejournal.org/stem-education-should-be-a-national-security-priority/>.

the capacity of the scientific base, develops the technical understanding of non-technologists, improves resilience to disinformation, and inspires interest in space.¹⁵⁵

The NDEA was designed to “promote the importance of science, mathematics, and foreign languages for students, authorize more than \$1 billion toward decreasing student loans, funding for education at all levels, and funding for graduate fellowships.”¹⁵⁶ According to the U.S. Senate, the NDEA was one of the most successful initiatives to bolster higher education and is directly attributed to increasing university enrollments from 3.6 million in 1960 to 7.5 million in 1970.¹⁵⁷ The NDEA helped the U.S. gain an advantage over the USSR during the space race and “ultimately played an important role in the U.S. victory in the Cold War.”¹⁵⁸

Harkening back to the fear that the U.S. lost the strategic edge over the Soviets during the space race, due to the USSR launch of Sputnik in 1957, the NSCAI recommends that the U.S. pass an NDEA II. The NSCAI recommends a second NDEA that focuses on developing digital talents, such as data science, computer science, mathematics, statistics, and information science, at the kindergarten through twelfth-grade levels and offering scholarships at the undergraduate, graduate, and doctorate

¹⁵⁵ Brahm, “STEM Education Should be a National Security Priority.”

¹⁵⁶ NSCAI, *National Security Commission on Artificial Intelligence*, 175.

¹⁵⁷ U.S. Senate, “Sputnik Spurs Passage of the National Defense Education Act,” October 4, 1957, https://www.senate.gov/artandhistory/history/minute/Sputnik_Spurs_Passage_of_National_Defense_Education_Act.htm.

¹⁵⁸ NSCAI, *National Security Commission on Artificial Intelligence*, 175.

levels. “Ultimately, the goal of NDEA II is to widen the digital talent pool by incentivizing programs for underrepresented Americans.”¹⁵⁹

Summary

Since Alan Turing’s conceptual design for AI applications in universal computers, the rate of technology kept pace with Moore’s Law, the observation that the number of transistors on a microchip doubles every two years.¹⁶⁰ Since the unveiling of the proverbial AI genie when Google DeepMind’s AlphaGo system defeated the internationally top-ranked Go player, Lee Sedol, in 2016, the abstract notion that AI can outperform humans at some complex tasks has been irrevocably proven, leading to an avalanche in publications, technical patents, and national policy changes to achieve a national security vision in the U.S. and China.¹⁶¹ The presidents of both countries established the strategic direction and priority to harness the potential of AI for national security (e.g. the ability to extrapolate large data sets). The most relevant application is the usage of AI to allow warfighters to bring big data to bear to analyze vast volumes of information that would be impossible for humans to process.

The DoD must accelerate change to become a data-centric organization or lose to international competitors who are able to achieve the asymmetric digital advantage. The NSCAI highlighted challenges to recruiting and retaining AI-related talent in the U.S.

¹⁵⁹ NSCAI, *National Security Commission on Artificial Intelligence*, 175.

¹⁶⁰ David Rotman, “We’re not prepared for the end of Moore’s Law,” *MIT Technology Review*, February 24, 2020, <https://www.technologyreview.com/2020/02/24/905789/were-not-prepared-for-the-end-of-moores-law/&clen=154567&chunk=true>.

¹⁶¹ Morgan and Cohen, *Military Trends and the Future of Warfare*, 60.

Government as a national security concern. Specifically, the inability of the government to compete with private-sector salaries, the cumbersome hiring process, the slow security clearance process, and what many STEM degree graduates perceive as not meaningful work all hinder the U.S. ability to maintain a competitive advantage over China, especially, considering the PRC's momentum in AI advancements since President Xi's 13th Five-Year Plan. The AI race against China is not the first time the U.S. overcame a talent deficit.

Technical and analytical cryptanalysts were recruited to break German and Japanese ciphers during WWII, many of which were women with backgrounds in mathematics, sciences, and foreign languages. The Space Race in the 1960s is another example of a national security event where the U.S. initially fell behind its competitor but overcame it by changing national policy and hiring brilliant and capable thought leaders in the field. The race for the atomic bomb, potentially the most consequential historical example, required a singular focus, ample national resources, and a visionary leader to recruit and direct some of the best scientists in the world while still offering scientific freedom for innovation. The next chapter provides the research methodology for this study. Specifically, the chapter details how the three case studies are compared against each other and against U.S. national strategies to gain an understanding of effective talent management practices and any areas for improvement in the U.S. and DoD AI strategies.

CHAPTER 3

RESEARCH METHODOLOGY

For the U.S. military to maintain a competitive advantage with modern technology, it must organize with the principles of purpose, teaming, and speed.
—Barry Scott, Naluahi Kaahaaina, and Christopher Stock,
“Innovation in the Military”

Introduction

This chapter covers the research methodology used to understand options for government and specifically military leaders to consider when tackling what the National Security Commission for Artificial Intelligence (NSCAI) deemed to be the most critical factor in maintaining the international leader in the Artificial Intelligence (AI) race with the People’s Republic of China (PRC).¹⁶² The primary research question is focused on how the U.S. can apply lessons learned pertaining to talent management from historical technological races—cryptanalysis during World War II (WWII), the race for the atomic bomb, and the space race—to maintain the competitive edge in the AI race. The secondary research questions are what talent management programs can be employed to support the United States (U.S.) in the AI race at the strategic level and how can the U.S. military overcome talent management barriers to foster the national AI strategy? This chapter explores the applicability of a qualitative research design, specifically, case study methodology, to reach a high ethical standard, underscored by credibility and transferability. The chapter covers qualitative methodology, data collection, data analysis, and ethical considerations.

¹⁶² NSCAI, *National Security Commission on Artificial Intelligence*.

Qualitative Methodology

Qualitative research is the systematic investigation of social phenomena including individual experiences, individual behavior, organizational functions, and how interactions shape relationships.¹⁶³ In qualitative research, the collected data is used to explore the underpinnings of why events occur, what happens and what is meant in a greater context.¹⁶⁴ There are common themes in available official government data that suggest the prerequisite for AI breakthroughs is rare talent.¹⁶⁵ To understand the current phenomena in talent management for the AI race between the U.S. and the PRC, a qualitative research methodology is the most appropriate, specifically a case study methodology.¹⁶⁶ Case studies are ideal when requiring a thorough description of the context, processes, or themes observed and lessons to be learned.¹⁶⁷ This case study's purpose is to discover themes from historical technological races to identify lessons learned to be applied to the current AI race between the U.S. and China.¹⁶⁸

¹⁶³ Arianne Teherani, Tina Martimianakis, Terese Stenfors-Hayes, Anupma Wadhwa, and Lara Varpio, "Choosing a Qualitative Research Approach," *Journal of Graduate Medical Education* 7, no. 4 (2015): 669-670, <https://doi.org/10.4300/JGME-D-15-00414.1>.

¹⁶⁴ Pamela Baxter and Susan Jack, "Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers," *The Qualitative Report* 13, no. 4 (December 4, 2008): 544-559, <http://www.nova.edu/ssss/QR/QR13-4/baxter.pdf>.

¹⁶⁵ NSCAI, *National Security Commission on Artificial Intelligence*.

¹⁶⁶ Creswell, *Qualitative Inquiry and Research Design*.

¹⁶⁷ *Ibid.*, 225.

¹⁶⁸ *Ibid.*

The first step in determining which case studies to use was to create screening criteria. The screening criteria used to identify case studies is:

1. A technological race during which the U.S. started from a position of disadvantage,
2. The personnel in the technological race required high competence in Science, Technology, Engineering, and Math (STEM) fields, and
3. The U.S. ultimately succeeded over an adversary in the race.

The case studies that met the screening criteria are the cryptanalysis efforts during WWII, the race for the atomic bomb during WWII, and the space race during the Cold War.

While there are several factors influencing the parity in AI achievements for the U.S. and China, talent and talent management may be developed in-depth by discovering common themes from historical breakthroughs in the case studies: cryptography during WWII, the race for the atomic bomb, and the space race. The themes are compared against each other and against official U.S. Government documents, the NSCAI, and a RAND Corporation study. “Binding the case studies ensured the study remained reasonable in scope.”¹⁶⁹ This study binds case studies based on definition and context: the definition is talent management during a time of significant government innovation, and the context is STEM-related work during a technological race.¹⁷⁰

¹⁶⁹ Baxter and Jack, “Qualitative Case Study Methodology,” 546.

¹⁷⁰ Ibid.

Rigor for Qualitative Studies

To add validity to the case study, triangulation, disconfirming evidence, researcher reflexivity, and collaboration was used within qualitative lens and paradigm assumptions.¹⁷¹ Triangulation is a “validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study.”¹⁷² The historical case studies’ themes include massing technical talent to solve a national problem during war, WWII, and the Cold War. Disconfirming evidence is like triangulation but then focuses on searching content to find evidence that disproves the themes. The talent management variables for each of the case studies are presented in a binary format. Using primary source testimonials and secondary source documents, the studies are reviewed through the talent management lens from the NSCAI in Figure 7. Researcher reflexivity is a procedure by which researchers self-disclose their assumptions, biases, and beliefs.¹⁷³ Finally, collaboration with committee members allowed for the refinement of research questions and challenging assumptions.¹⁷⁴ Outside perspectives on researcher bias further add credibility to the qualitative research design.

While biases cannot be completely omitted from the analysis, biases are mitigated through thorough research and collaboration with committee members and peers with a diversity of thought. The study used intelligence analysis techniques in the process of

¹⁷¹ John W. Creswell and Dana L. Miller, “Determining Validity in Qualitative Inquiry,” *Theory into Practice* 39, no. 3 (Summer 2000): 125-127, https://people.ucsc.edu/~ktellez/Creswell_validity2000.pdf.

¹⁷² Ibid., 126.

¹⁷³ Ibid., 127.

¹⁷⁴ Ibid., 128.

data collection and analysis. The study used diverging points of view and primary source materials to add analytical rigor. Several frameworks have been created to evaluate the rigor or assess the trustworthiness of qualitative data.¹⁷⁵ One way to establish trustworthiness is transferability, which is the degree to which salient conditions overlap or match.¹⁷⁶ The intent of the case studies is to gain insight and understanding of a particular situation or phenomenon; therefore, an instrumental case study will be used to gain understanding. The analytical tables provide the means to compare the case studies against each other to discover which salient conditions overlap.

Data Collection

Data collection for the three case studies came from historical non-fiction books, recorded interviews with the scientists on the Manhattan Project, official U.S. and PRC Government publications, RAND Corporation studies, and government archival records to ascertain themes, assertions, and overarching descriptions. The study used compilations of primary-source recorded interviews with, journals by, and books on scientists behind the three case studies to discern talent management variables from the viewpoint of the scientists. In official U.S. Government publications on AI, word searches on superlatives (e.g., most or greatest) yielded results pertaining to talent and talent management. Commonalities in the cases are rare talent to overcome technological obstacles for a high-stakes U.S. Government endeavor.

¹⁷⁵ Baxter and Jack, “Qualitative Case Study Methodology,” 544-559.

¹⁷⁶ Rudolf R. Sinkovics, Elfriede Penz, and Pervez N. Ghauri, “Enhancing the Trustworthiness of Qualitative Research in International Business,” *Management International Review* 48 (December 2008): 689-714, DOI 10.1007/s11575-008-0103-z.

The qualitative case study seeks first-hand accounts from the people behind the aforementioned technological breakthroughs to understand their motivations, technical acumen, and preferred talent management principles that lent to significant national security advantages. The study weighed first-hand accounting of historical events heavily to analyze common themes from the cases for cryptanalysis during WWII and the race for the atomic bomb. While there are interviews with scientists during the space race, they are more sparse. Evidence of this issue is apparent in the analysis tables.

Data Analysis

Chapter 6 within the NSCAI provides several recommendations to overcome challenges to the digital workforce needed for national security means. The chapter is focused on improving technical talent in government.¹⁷⁷ According to the NSCAI, digital expertise is the most important requirement for government modernization; however, few parts of government have adequately invested in building a digital workforce to include the Department of Defense.¹⁷⁸ Chapter 6 of the NSCAI provides a lens through which the historical case studies may be analyzed. Specifically, the lens' structure is tailored to how organizations organize a talent management system to support a highly-skilled workforce, recruit AI experts and college academics, build a workforce through education and training, and employ a digital workforce to solve the U.S. Government's

¹⁷⁷ NSCAI, *National Security Commission on Artificial Intelligence*, 121.

¹⁷⁸ Ibid.

most technical problems.¹⁷⁹ Figure 7 below provides the overarching themes the U.S. Government needs to take to expand its digital and AI workforce.

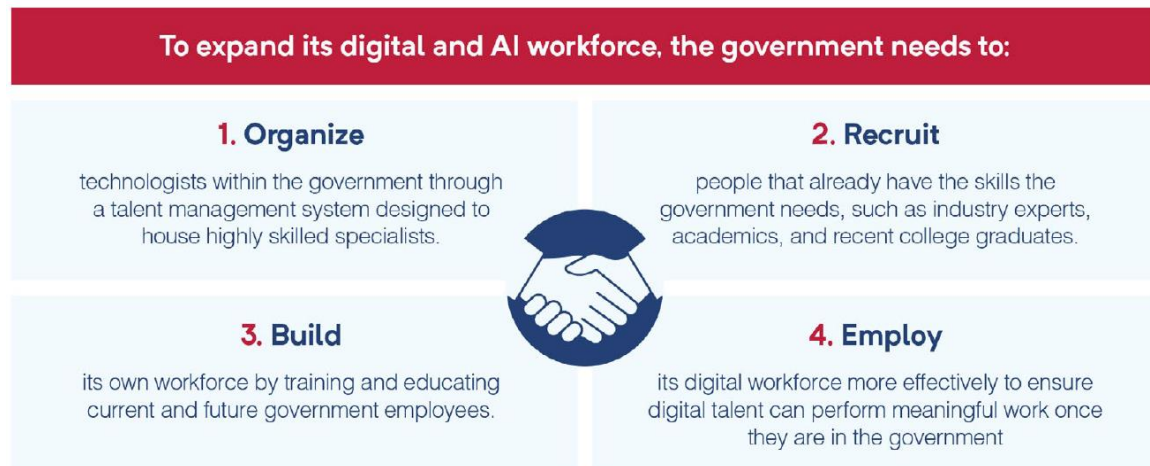


Figure 7. Recommendations from NSCAI to Build a Digital and AI Workforce

Source: National Security Commission on Artificial Intelligence (NSCAI), *Final Report: National Security Commission on Artificial Intelligence* (Washington, DC: NSCAI, March 19, 2021), 121, <https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf>.

Scientists quoted in collected primary and secondary source materials reference social phenomena related to the four sections recommended in the NSCAI Final Report: organize, recruit, build, and employ. Analysis of the case studies focuses on discovering themes in talent management using the above lens. The themes discovered included the following descriptions that will become variables for analytical tables:

1. The creation of an organization with clearly definable goals under centralized leadership,

¹⁷⁹ NSCAI, *National Security Commission on Artificial Intelligence*, 121.

2. An environment with a sense of urgency,
3. A diverse team of people representing more than one national origin, color, religion, socioeconomic stratum, and sexual orientation,¹⁸⁰
4. A team with a shared sense of value in the work,
5. Recruitment direct from universities by renowned members in the scientific field to which members were being recruited, and
6. An environment where the decision-makers value members for expertise.

Table 2 below depicts the three cases: cryptography during WWII as “A,” the race for the atomic bomb during WWII as “B,” and the space race as “C.” If the variable is applicable to the case, the output will be a +, whereas, if the variable is not applicable, the output will be a -. If the phenomenon was not observed, the field is blank.

Table 2. Data Analysis of Variables for Case Studies						
Case	V1	V2	V3	V4	V5	V6
A: Cryptanalysis	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -
B: Race for A bomb	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -
C: Space Race	+ or -	+ or -	+ or -	+ or -	+ or -	+ or -

Source: Created by author.

The completed tables for analysis are presented in Chapter 4. Data sets for analysis remain strictly from unclassified sources and preference is toward interviews

¹⁸⁰ Kotter, *Leading Change*.

with scientists and engineers on the projects during the three case study events. Figure 8 below provides an overview of the case study methodology starting with collected sources. The screening criteria produce three case studies: Cryptanalysis during WWII, the Race for the Atomic Bomb, and the Space Race. The six case study variables for the data analysis tables are listed on the far right.

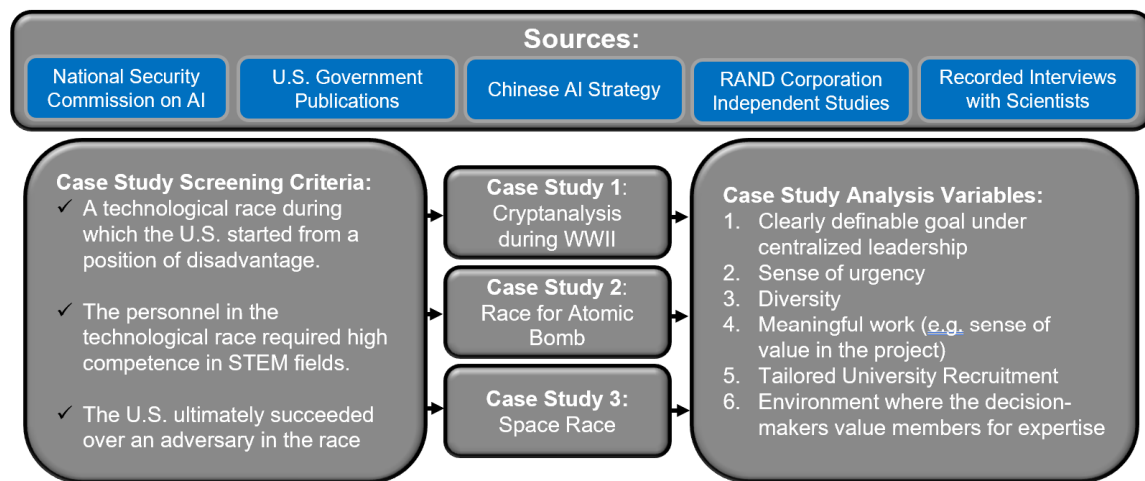


Figure 8. Summary of Case Study Methodology

Source: Created by author.

Ethical Considerations

There are secondary source publications that are contradictory to the government publications used in this study. The pace of the AI race requires analysis of the most updated research data. Most publications contrary to supporting this study derived raw data from 2017 and earlier. As with Moore's Law, the pace of technology innovation remained consistent with the exponential growth Gordon Moore predicted with the

explosion of hyperconnectivity, big data, and AI.¹⁸¹ Similarly, this study may become obsolete in the next two years. All data used in this study is from unclassified sources. There may be data available from sensitive sources and methods that could negate this study. Finally, there are no conflicts of interest during the course of this study due to financial concerns or interested party concerns.

Summary

The research methodology to best explore potential answers to the research question of how the U.S. may learn from scientists during previous technological races to achieve superiority in the AI race between the U.S. and PRC is qualitative research.¹⁸² The study examines three case studies: cryptanalysts during WWII, the race for the atomic bomb, and mathematicians during the Space Race. The intent of the case studies is to gain insight and understanding of a particular situation or phenomenon; therefore, an instrumental case study will be used to gain understanding. This chapter provided two frameworks to analyze the three case studies and compare the case studies against recommendations from the RAND Corporation. The completed tables for analysis are presented in Chapter 4.

¹⁸¹ Mike Gianfagna, “What is Moore’s Law?” Synopsys, June 30, 2021, <https://www.synopsys.com/glossary/what-is-moores-law.html>.

¹⁸² Creswell, *Qualitative Inquiry and Research Design*, 40.

CHAPTER 4

ANALYSIS

AI competition will not be won by the side with the best technology. It will be won by the side with the best, most diverse and tech-savvy talent.

—National Security Commission on Artificial Intelligence,
Final Report: National Security Commission on Artificial Intelligence

Introduction

This chapter provides a comprehensive analysis of the talent management principles that underpin the three case studies: cryptanalysis during World War II (WWII), the race for the atomic bomb, and the space race, to achieve superior performance in the technological race for Artificial Intelligence (AI) leadership between the United States (U.S.) and the People’s Republic of China (PRC). The national AI strategies for both the U.S. and the PRC point to talent management as the most influential aspect of achieving a competitive advantage in the AI race. The primary research question is how can the U.S. apply lessons learned pertaining to talent management from historical technological races to maintain the competitive edge in the AI race. The secondary research questions are what talent management programs can be employed to support the U.S. in the AI race at the strategic level and how can the U.S. military overcome talent management barriers to foster the national AI strategy?

The National Security Commission on Artificial Intelligence (NSCAI) provides recommendations to overcome challenges to the digital workforce needed for national security means binned into four categories: Organize, Recruit, Build, and Employ. Analysis of the three historical case studies focuses on discovering themes in talent management (e.g. recruit, organize, build, and employ). This chapter is organized into

two main sections: Case Study Analysis and Comparison of the Case Studies Against the U.S. AI Approach. It concludes with a summary. The Case Study Analysis is further subdivided into three case studies in chronological order: Cryptanalysis during WWII, The Race for the Atomic Bomb, and The Space Race.

Case Study Analysis

Analysis of the cryptanalysis during WWII, the race for the atomic bomb, and the space race focus on talent management-related themes discovered in primary and secondary source materials. The following subsections provide a historical summary of talent management themes for later comparison. The talent management variables which are most pertinent to the case studies are clearly definable goals under centralized leadership, sense of urgency, talent pool diversity, meaningful work (e.g. sense of value in the project), tailored university recruitment, and, an environment where the decision-makers valued members for expertise.

Cryptanalysis during WWII

In September 1941, Rear Admiral Leigh Noyes wrote a letter to the president of Radcliffe College, the women's counterpart to Harvard. This initial connection between Rear Admiral Noyes and Ada Comstock ignited the women cryptanalyst recruiting program. Ada Comstock, at the request from the U.S. Navy, connected with deans and presidents at the Seven Sisters Ivy League schools: Bryn Mawr, Mount Holyoke, Barnard, Vassar, Smith, and Wellesley, to identify women based on their educational prowess, ability to keep a secret, U.S. citizenship, and lack of close ties with other

nations.¹⁸³ On October 31 and November 1, 1941, the women's college leaders met at Mount Holyoke in Massachusetts during which Ada Comstock distributed Naval cryptanalysis instruction materials.¹⁸⁴

The college leaders sent letters to women with high academic performance, usually in the top 10% of their class, and character traits: grit, gumption, loyalty, inviting them to a private interview during which the leaders asked two questions.¹⁸⁵ “Did the women like crossword puzzles and were they engaged to be married?”¹⁸⁶ The U.S. Navy's recruiting program aimed to find women with backgrounds in foreign languages, English, Science, Technology, Engineering, and Math (STEM) “to embark on a field called ‘cryptanalysis’.”¹⁸⁷ “In all, 197 women received a secret invitation. The women attended weekly training courses in cryptanalysis during which the college professors led the students through the material.¹⁸⁸ Throughout their training, the women learned cryptographic security, basic and advanced cryptography, International Business Machines theory, code compilation, cryptanalytic worksheets preparation, and foreign languages: Japanese, German, Italian, French, Spanish, and Portuguese.¹⁸⁹ Upon

¹⁸³ Mundy, *Code Girls*, 12.

¹⁸⁴ *Ibid.*, 14.

¹⁸⁵ *Ibid.*, 4-5.

¹⁸⁶ *Ibid.*, 4.

¹⁸⁷ *Ibid.*, 5.

¹⁸⁸ *Ibid.*, 6.

¹⁸⁹ Wilcox, *Sharing the Burden*, 5.

completion, seventy-four women took jobs in Washington D.C. as military civilians, making \$1,620 a year.¹⁹⁰ Figure 9 below depicts a typical cryptanalyst classroom.



Figure 9. A Cryptanalysts' Classroom inside Arlington Hall Station

Source: Jennifer Wilcox, *Sharing the Burden: Women in Cryptology during World War II* (Fort George G. Meade, MD: Center for Cryptologic History, National Security Agency, 1998), 5, https://www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/sharing_the_burden.pdf.

Goucher College, known for the caliber of its science departments, is a four-year women's college in Baltimore, Maryland.¹⁹¹ After the attack on Pearl Harbor, the Secretary of War, Henry Stimson, requested a list of the best seniors in the field of sciences from his cousin who happened to be the dean at Goucher College.¹⁹² Again, the

¹⁹⁰ Mundy, *Code Girls*, 138.

¹⁹¹ *Ibid.*, 6.

¹⁹² *Ibid.*

recruited women attended a weekly class on cryptanalysis with a Pulitzer Prize winner English professor, Ola Winslow, and a Naval officer.¹⁹³ “As war engulfed the nation, the secret recruiting summonses continued to go out in 1942, 1943, and 1944 as cryptanalysis proved crucial to disrupting enemy operations and saving Allied lives.”¹⁹⁴ While the U.S. Navy focused on college recruitment, the U.S. Army targeted women in the job consistently available to women with quality education, a school teacher.¹⁹⁵ The U.S. Army campaigned to recruit women at teaching colleges as well as school teachers in the field who were interested in a career change in remote cities and rural communities.

Recruiting cryptanalysts to decipher German and Japanese encrypted war codes was of the highest priority for the U.S. War Department. During the interwar period, the U.S. military intelligence community maintained only a small cryptanalysis contingent. In 1941, when America entered the war in earnest, the cryptanalysis effort in the United Kingdom (UK) was more capable than that of the Americans; however, the American cryptanalysis industry ramped up so quickly, that it outpaced Bletchley Park.¹⁹⁶ The massive emphasis on cryptanalysis in the U.S. led to a sense of urgency that may only be present in the event of total war. “The urgency of the work was harrowing.”¹⁹⁷ From the 1930s to 1943, the U.S. admitted women to military service, and most men served in a two-front war. “In July 1943, there were 269 male officers, 641 enlisted men, 96 female

¹⁹³ Mundy, *Code Girls*, 6.

¹⁹⁴ *Ibid.*, 7.

¹⁹⁵ *Ibid.*, 8.

¹⁹⁶ *Ibid.*, 18.

¹⁹⁷ *Ibid.*, 141.

officers, and 1,534 enlisted women cryptanalysts.”¹⁹⁸ They represented a cross-section of U.S. women “from different economic and social classes, from all parts of the country, and from a multitude of racial origins and religions.”¹⁹⁹

At their peak, women comprised 80% of the total cryptanalyst force in Washington, DC. Additionally, due to Eleanor Roosevelt’s advocacy, 12-15% of the cryptanalysts at Arlington Hall were to be black.²⁰⁰ Not only were cryptanalysts during WWII a diverse group, but the U.S. Army-led Arlington Hall was also particularly inclusive in its approach to novel ideas. “To a striking degree, Arlington Hall was a ‘flat’ organization, an egalitarian work culture in which good ideas could emerge from any quarter and be taken seriously.”²⁰¹ By their own testimony in interviews with Liza Mundy, the cryptanalysts stated that the work environment was daunting, tedious, frustrating, and inculcated sadness and a sense of failure but the importance of the national security mission kept them eager on the task.²⁰² The cryptanalysts lived in sub-optimal living conditions and sub-optimal pay to have the opportunity to contribute to the war effort. The following excerpts came from interviews with women cryptanalysts:

I felt so lucky to be in this small, interesting unit and to feel my work had some value. Never in my life since have I felt as challenged as during that period, like

¹⁹⁸ Mundy, *Code Girls*, 182.

¹⁹⁹ *Ibid.*, 175.

²⁰⁰ *Ibid.*, 208.

²⁰¹ *Ibid.*, 211.

²⁰² *Ibid.*, 141.

Hegel's idea about when the needs of society and the needs of an individual come together. We were fulfilled.²⁰³

Genevieve Grotjan, a junior mathematician with “less than a year of on-the-job training,” along with other cryptanalysts, theorized the Japanese Purple machine was using a switching device rather than wheels to transform the letters.²⁰⁴ After pouring through historical Japanese long messages, Genevieve “found the repetitions, uncovered the cycles, and confirmed the hypothesis,” ultimately leading to breaking the Purple machine.²⁰⁵ Not only did the Purple cipher give the Allies insight into Japanese thinking, but it also “provided ‘the most important source of strategically valuable, long-term intelligence’ including that of the fascist and collaborationist governments in Europe.”²⁰⁶ Using the Purple machine, the Japanese Ambassador to Germany, General Baron Hiroshi Oshima, provided descriptions of German fortifications along the French coast that would later be invaluable when Allied commanders planned the D-Day invasion.²⁰⁷ In later years, women including Genevieve Grotjan began leading top cryptanalysis teams.

In summary, based on the above testimonials by the cryptanalysts during WWII, there were clearly definable goals to break Japanese and German ciphers. However, there was a lack of centralized leadership in the U.S. Government, which led to intense competition between the U.S. Navy and U.S. Army. All other talent management themes

²⁰³ Mundy, *Code Girls*, 157.

²⁰⁴ *Ibid.*, 98-99.

²⁰⁵ *Ibid.*, 99.

²⁰⁶ *Ibid.*, 101.

²⁰⁷ *Ibid.*, 102.

are present: a sense of urgency, talent pool diversity, meaningful work, tailored university recruitment, and an environment where the decision-makers valued members for expertise. Table 3 below provides a summary of the themes discovered from analyzing the Cryptanalysis during WWII where each variable is annotated with a “+”.

Table 3. Completed Analysis of Variables for Cryptanalysis during WWII						
Case	Goals and leadership	Urgency	Diversity	Meaning	University Recruitment	Valued
Cryptanalysis	+	+	+	+	+	+

Source: Created by author.

The Race for the Atomic Bomb

In the 1930s, as fascism crept over the European continent, brilliant scientists, engineers, mathematicians, and technologists fled to the U.S. They fled Nazi or Mussolini regimes, delivering a powerful combination of talented and politically motivated émigrés.²⁰⁸ This influx led to the U.S. having a world-class capacity in science and technology.²⁰⁹ By the time the U.S. entered WWII, it had domestic pools of talent from which to enlist for a special national security project. The diverse set of talent not only brought WWII to an end but the U.S. scientists contributing to the war effort pulled the

²⁰⁸ David Kaiser, interview by Cindy Kelly, Voices of the Manhattan Project, Massachusetts Institute of Technology, September 8, 2014, <https://www.manhattanprojectvoices.org/oral-histories/david-kaisers-interview>.

²⁰⁹ Ibid.

center of gravity for science and technology from Europe, leading to the U.S. becoming the scientific center of the world.²¹⁰

In September 1942, the U.S. Army appointed Brigadier General Leslie Groves as the head of the Army Corps of Engineers and assigned him responsibility for the atomic bomb program, code-named the Manhattan Project.²¹¹ A decisive and demanding leader, General Groves propelled the project forward.²¹² He selected three primary sites to manufacture the atomic bomb: Oak Ridge, Tennessee for uranium enrichment, Los Alamos, New Mexico for weapons research, and Hanford, Washington to produce plutonium from the uranium isotope U-238.²¹³ The reorganization of the atomic project under the Department of the Army with an Army general at the helm “renewed the project’s sense of urgency.”²¹⁴ The U.S. set up the Military Policy Committee that included one representative each from the Army, the Navy, and the Office of Scientific Research and Development so that scientists would have better access to decision-makers.²¹⁵ The new organizational structure, which eliminated previous parallel but

²¹⁰ Kaiser interview.

²¹¹ Groves interview.

²¹² Gosling, *The Manhattan Project*, 37; Kristen D. Burton, “Destroyer of Worlds: The Making of an Atomic Bomb,” The National WWII Museum, July 16, 2020, <https://www.nationalww2museum.org/war/articles/making-the-atomic-bomb-trinity-test>.

²¹³ Burton, “Destroyer of Worlds.”

²¹⁴ Gosling, *The Manhattan Project*, 15.

²¹⁵ *Ibid.*, 15-16.

separate structures, helped remedy early deficiencies that slowed the decision-making process.²¹⁶ According to Department of Energy historian, Francis G. Gosling:

The exigencies of war, Groves held, required scientists to move from laboratory research to development and production in record time. Though traditional scientific caution might be short-circuited in the process, there was no alternative if a bomb was to be built in time to be used in the current conflict. As everyone involved in the Manhattan Project soon learned, Groves never lost sight of this goal and made all his decisions accordingly.²¹⁷

J. Robert Oppenheimer, the first director of the newly created Los Alamos National Laboratory in New Mexico, advocated keeping Los Alamos National Laboratory an academic community.²¹⁸ Every scientist “had the impression that Oppenheimer cared what each particular person was doing.”²¹⁹ “In talking to someone he made it clear that that person’s work was important for the success of the whole project.”²²⁰ Oppenheimer, who was opposed to serving in uniform, assembled a group of theoretical physicists and other scientific staff averaging twenty-five years of age, primarily consisting of his closest friends and colleagues. He spent the first three months of 1943 crisscrossing the country personally traveling to theoretical physics and radiation laboratories at Stanford University, University of Minnesota, Princeton University,

²¹⁶ Gosling, *The Manhattan Project*, 16.

²¹⁷ Ibid.

²¹⁸ Ibid., 37.

²¹⁹ Ibid.

²²⁰ Rhodes, *The Making of the Atomic Bomb*, 570.

Cornell University, and Massachusetts Institute of Technology, to name a few, to recruit scientists to work at Los Alamos.²²¹

This effort proved to be successful and led to a population growth that doubled every four months at Los Alamos.²²² “Many of the scientists objected to working as commissioned officers and feared that the military chain of command was ill-suited to scientific decision-making.”²²³ In particular, Robert F. Bacher and Isidor I. Rabi from the Massachusetts Institute of Technology’s Radiation Laboratory thought a military environment was not conducive to scientific research, to which Oppenheimer promised that the laboratory would remain civilian through 1943.²²⁴ Oppenheimer created an environment where creative scientific ideas could flourish. Taking cues from scientists at Los Alamos, he orchestrated a forum, or colloquium, to foster open-ended brainstorming sessions with colleagues, students, and newcomers.²²⁵ Furthermore, the Los Alamos laboratory organizational chart was a circle.²²⁶ The flat organizational structure was meant to connect every possible group to every other group. Oppenheimer argued that

²²¹ Gosling, *The Manhattan Project*, 38; Rhodes, *The Making of the Atomic Bomb*; Oppenheimer interview.

²²² Oppenheimer interview.

²²³ Gosling, *The Manhattan Project*, 37.

²²⁴ Ibid.

²²⁵ Kaiser interview.

²²⁶ Ibid.

members of each group needed to be in a room together on a regular basis to sort through difficult areas of research or experimentation.²²⁷

The scientists behind the race for the atomic bomb had various motivations for contributing to the project. In an interview with Raymond Sheline, a chemist at Columbia University and a member of the Special Engineer Detachment at Oak Ridge and Los Alamos, he recalled being recruited by Harold Urey, Nobel Laureate in Chemistry and Physics, to work on the Manhattan Project at Columbia University.²²⁸ Sheline was subsequently drafted into the Army at the rank of a Private and had to attend basic training at Camp Claiborne, Louisiana, then continued work on electron micrographs of corrosive dust at Columbia University.²²⁹ In June 1945, Sheline transferred to Los Alamos, where, by his own account, he “worked with the greatest scientists in the world, Enrico Fermi, Niels Bohr, Hans Bethe, and many others.”²³⁰ At Los Alamos, he was an Army Staff Sergeant but had a Major in the Army who worked under his direction.

Hans Bethe, a German-American physicist and Nobel Prize winner who was head of the Theoretical Division at Los Alamos, and Enrico Fermi, Nobel Prize-winning physicist and the first man to create and control a nuclear chain reaction, were galvanized

²²⁷ Kaiser interview.

²²⁸ Raymond Sheline, interview by Jonathan Sheline, Voices of the Manhattan Project, February 6, 2009, <https://www.manhattanprojectvoices.org/oral-histories/raymond-shelines-interview-2009>.

²²⁹ Ibid.

²³⁰ Ibid.

by the prospect of actively opposing Nazism.²³¹ While the scientists behind the race for the atomic bomb did not speak much about diversity in the research groups, the children of the scientists remarked on the diversity of fellow school children at Los Alamos. In an interview with Ellen Bradbury Reid, whose dad was a chemist at Los Alamos, she recalled how the “high school class was very, very mixed.”²³² There were many European Jewish, Hispanic, and Native American kids of workers at the site who all played together in and outside of school.²³³

Scientists had scientific freedom to explore the realm of possibility and the scientists were intrinsically motivated by the possibility that the bomb could help end the war, albeit not all scientists were supportive of dropping the atomic bomb on Japan. Regardless of their motivations to join the Manhattan Project, they were instrumental in not only ending WWII in 1945 but also, “placing the U.S. in a position of global power not held by any other nation following the war’s end.”²³⁴ The race for the bomb was to keep such power out of Nazi hands and to end WWII. “The Manhattan Project pushed humanity across the threshold into a new atomic age that forever altered the nature of conflict and the fear of global warfare.”²³⁵

²³¹ Hans Bethe, interview by Martin J. Sherwin, *Voices of the Manhattan Project*, Ithaca, NY, May 5, 1982, <https://www.manhattanprojectvoices.org/oral-histories/hans-bethes-interview-1982-part-1>.

²³² Ellen Bradbury Reid, interview by Cindy Kelly, *Voices of the Manhattan Project*, Los Alamos, NM, July 31, 2013, <https://www.manhattanprojectvoices.org/oral-histories/ellen-bradbury-reids-interview>.

²³³ Ibid.

²³⁴ Burton, “Destroyer of Worlds.”

²³⁵ Ibid.

After delivering a proof of concept, the project expanded across the U.S. During the height of the race for the atomic bomb, approximately 130,000 people worked at thirty-seven facilities across the U.S. The total cost of the Manhattan Project was almost \$2 billion U.S. dollars and took two and a half years to complete. The scientists behind the race for the atomic bomb had a clearly definable goal (successfully detonate a uranium or plutonium bomb) under centralized leadership (General Leslie Groves), a sense of urgency, strategically meaningful work, tailored university recruitment (using Nobel Laureates in STEM), and, an environment where the decision-makers valued members for expertise. Finally, many of the initiators of the race for the atomic bomb were world-class physicists who happen to be Jewish escapees from Nazi Germany.²³⁶

Table 4 below provides a summary of the themes discovered from analyzing the Race for the Atomic Bomb where each variable is annotated with a “+”.

Table 4. Completed Analysis of Variables for the Race for Atomic Bomb						
Case	Goals and leadership	Urgency	Diversity	Meaning	University Recruitment	Valued
Race for A-bomb	+	+	+	+	+	+

Source: Created by author.

²³⁶ Richard Rhodes, interview by Cindy Kelly, Voices of the Manhattan Project, Washington, DC, February 13, 2013, <https://www.manhattanprojectvoices.org/oral-histories/richard-rhodes-interview>.

The Space Race

When the Union of Soviet Socialist Republics (USSR) outpaced the U.S. in scientific discoveries after WWII, Edward Teller, nuclear weapons designer, stated that the U.S. had lost a battle more important and greater than Pearl Harbor.²³⁷ Similar to the race to break adversary cryptographic codes and the race for the atomic bomb, talent underpinned the space race. In *American Moonshot: John F. Kennedy and the Great Space Race*, Douglas Brinkley recounts how both the U.S. and USSR were keen on expatriating the scientists from the secret missile laboratory, Peenemünde, in Germany, to work on their long-range missile initiatives.²³⁸ Dr. Wernher von Braun, a rocket developer at Peenemünde, who surrendered to U.S. forces during WWII, was one of the most important champions of space exploration in the twentieth century.²³⁹ Under military Operation Paperclip, Dr. Wernher von Braun and 125 scientists worked with the U.S. Army to develop ballistic missiles after WWII.²⁴⁰

In the aftermath of the Sputnik 1 launch in 1957, U.S. President Eisenhower's Congress reacted rapidly by passing the National Space Act in 1958. The act transformed the National Advisory Committee for Aeronautics (NACA) into NASA with the

²³⁷ Douglas Brinkley, *American Moonshot: John F. Kennedy and the Great Space Race* (New York: Harper, 2019).

²³⁸ Ibid.

²³⁹ Jennifer Harbaugh, ed., "Biography of Wernher Von Braun," National Aeronautics and Space Administration, August 3, 2017, <https://www.nasa.gov/centers/marshall/history/vonbraun/bio.html>.

²⁴⁰ Ibid.

increased role of space added to the aeronautical task. NASA created the Space Task Group at Langley, which transitioned the U.S. into the manned space flight program.²⁴¹ Two years later, Dr. von Braun's rocket team transferred from the U.S. Army to NASA at which time Dr. von Braun "became director of NASA's Marshall Space Flight Center and the chief architect of the Saturn V launch vehicle, the super booster that would propel Americans to the moon."²⁴² The U.S. sense of urgency in reaction to the USSR's achievements in space exploration came from the top of the U.S. Government, the President.

In an interview with NASA's Dr. John O. Annexstad, he stated that after President John F. Kennedy proclaimed the U.S. would go to the moon, there was a rush to "desperately put everything together."²⁴³ It was not until the push for the moon that NASA had a cadre of people to conduct moon landing experiments. They outsourced contractors and had issues interfacing with the contractors in industry and academia. According to Dr. Annexstad, "it was a very kind of confusing type of situation."²⁴⁴ In interviews with several scientists who worked at the Johnson Space Center, they remarked on the speed at which personnel joined the space program and overall progress after President Kennedy set the national space agenda.

²⁴¹ Robert F. Thompson, interview by Kevin M. Rusnak, NASA Johnson Space Center Oral History Project, Houston, TX, August 29, 2000, https://historycollection.jsc.nasa.gov/JSCHistoryPortal/history/oral_histories/ThompsonRF/RFT_8-29-00.pdf.

²⁴² Harbaugh, "Biography of Wernher Von Braun."

²⁴³ John O. Annexstad, interview by Carol Butler, NASA Johnson Space Center Oral History Project, Houston, TX, March 15, 2001, https://historycollection.jsc.nasa.gov/JSCHistoryPortal/history/oral_histories/AnnexstadJO/AnnexstadJO_3-15-01.htm.

²⁴⁴ Harbaugh, "Biography of Wernher Von Braun."

In many interviews with scientists and astronauts during the space race, they talk about the recruitment of astronauts from the military test pilot community. There is not enough information to support tailored university recruitment of scientists during the space race. Many of the space exploration strategists behind NACA and then early NASA successes came from Operation Paperclip. Tailored university recruitment and diversity are not present in reviewing interviews with scientists behind the space race. While the story behind NASA's human computers, the women scientists who conducted calculations for the Apollo missions, received publicity with the book by Margot Lee Shetterly, *Hidden Figures*, there were not many minorities in the early days at NASA.²⁴⁵ In an interview with Gloria R. Champine, she described the lack of diversity during the space race and its effects on equal opportunities over several decades.²⁴⁶

Because of the national agenda to send a U.S. astronaut to the moon, the scientists behind the space race shared sentiments about their contributions to a larger, meaningful project. During the space race, there was a national campaign to boost the American imagination for space flight. Americans saw space exploration posters and flyers everywhere that boosted morale and intrinsic motivation to support the national space

²⁴⁵ Margot Lee Shetterly, *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race* (New York: William Morrow, 2016); Gloria R. Champine, interview by Sandra Johnson, NASA Headquarters, NACA Oral History Project, Newport News, VA, May 1, 2008, https://historycollection.jsc.nasa.gov/JSCHistoryPortal/history/oral_histories/NACA/ChampineGR_5-1-08.htm.

²⁴⁶ Champine interview.

initiative.²⁴⁷ An employee's sense of value in the project appears to be tied to external value and an environment where the decision-makers value members for expertise.

In the case of the space race, the sense of urgency was so high that program leaders valued scientists for their niche capabilities. In summary, the scientists behind the space race attribute clearly definable goals under centralized leadership, a sense of urgency, meaningful work, and an environment where the decision-makers valued workers for expertise as being talent management principles that led to succeeding in the space race. Table 5 provides a summary of the variable for the space race.

Table 5. Completed Analysis of Variables for the Space Race						
Case	Goals and leadership	Urgency	Diversity	Meaning	University Recruitment	Valued
Space Race	+	+	-	+	-	+

Source: Created by author.

Table 6 below depicts the three cases: cryptography during WWII as “A,” the race for the atomic bomb during WWII as “B,” and the space race as “C.” The talent management themes central to each of these case studies are listed for each column:

V1. Clearly definable goals under centralized leadership,

V2. Sense of urgency,

²⁴⁷ Ronald C. Woods, interview by Rebecca Wright, NASA Headquarters, NACA Oral History Project, Houston, TX, March 28, 2012, https://historycollection.jsc.nasa.gov/JSCHistoryPortal/history/oral_histories/NASA_HQ/Experts/WoodsRC/WoodsRC_3-28-12.pdf.

V3. Diversity,

V4. Meaningful work (e.g. sense of value in the project),

V5. Tailored University Recruitment, and,

V6. Environment where the decision-makers value members for expertise. If the variable is applicable to the case, the output will be a +, whereas, if the variable is not applicable, the output will be a -.

Table 6. Completed Analysis of Variables 1 – 6 for Case Studies						
Case	V1	V2	V3	V4	V5	V6
A: Cryptanalysis	+	+	+	+	+	+
B: Race for A-bomb	+	+	+	+	+	+
C: Space Race	+	+	-	+	-	+

Source: Created by author.

There is only one case study that focuses on cultivating pools of students for future Science, Technology, Engineering, and Math (STEM) work within the U.S. Fear that the U.S. lost the strategic edge over the Soviets during the space race, John F. Kennedy championed the National Defense Education Act while in congress.²⁴⁸ The NSCAI recommends that the U.S. pass a National Defense Education Act II to focus on developing digital talents, such as data science, computer science, mathematics, statistics, and information science, at the kindergarten through twelfth-grade levels and offering

²⁴⁸ Brinkley, *American Moonshot*.

scholarships at the undergraduate, graduate, and doctorate levels.²⁴⁹ “Ultimately, the goal of NDEA II is to widen the digital talent pool by incentivizing programs for underrepresented Americans.”²⁵⁰ According to the 2018 Committee on STEM Education (CoSTEM) report, “basic STEM concepts are best learned at an early age—in elementary and secondary school—because they are the essential prerequisites” for a lifetime in the workplace.²⁵¹ The 2018 CoSTEM strategic plan coincides with the recommendations from the NSCAI to build a future AI-enabled workforce.

Summary

This chapter provided a comprehensive analysis of the talent management principles that underpin the three case studies: cryptanalysis during WWII, the race for the atomic bomb, and the space race, to achieve superior performance in the technological race for AI leadership between the U.S. and China. Using the NSCAI’s four categories for talent management as a lens, the analysis of historical case studies focused on means to organize, recruit, build and employ STEM experts. Primary source interviews with experts behind the three case studies identify inferences of talent management principles: clearly definable goals under centralized leadership, sense of urgency, diversity, a sense of value in the project, tailored university recruitment, and an environment where the decision-makers value members for their expertise. The following

²⁴⁹ NSCAI, *National Security Commission on Artificial Intelligence*, 175.

²⁵⁰ *Ibid.*

²⁵¹ *Ibid.*, v.

chapter provides conclusions from the analysis in Chapter 4, other findings discovered that answer the primary and secondary research questions, and areas for future research.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

A lack of national urgency is dangerous at a time when underlying weaknesses have emerged in our AI ecosystem that impair innovation, and when viewed against the backdrop of China's state-directed AI progress.

—National Security Commission on Artificial Intelligence,
Final Report: National Security Commission on Artificial Intelligence

Introduction

This chapter provides a summary of conclusions and findings following an analysis of the talent management principles that underpin the three case studies: cryptanalysis during World War II (WWII), the race for the atomic bomb, and the space race. The national Artificial Intelligence (AI) strategies for both the U.S. and the People's Republic of China (PRC) point to talent management as the most influential aspect of achieving a competitive advantage in the AI race. The primary research question is how can the U.S. apply lessons learned pertaining to talent management from historical technological races to maintain the competitive edge in the AI race. The secondary research questions are what talent management programs can be employed to support the U.S. in the AI race at the strategic level and how can the U.S. military overcome talent management barriers to foster the national AI strategy? This chapter is organized into four sections: Conclusions, Findings, Future Research, and Summary.

Conclusions

Despite President Donald Trump signing Executive Order 13859, "American AI Initiative," in February 2019, the U.S. Government and, in particular, the Department of Defense (DoD), has not realized the profound impact that AI has on national security.

Thus, the DoD has not created the ways to foster the means of an AI-ready workforce to meet modern warfare requirements. According to the National Security Commission on Artificial Intelligence (NSCAI), the most vital resource to achieving AI readiness is to create a digital workforce. The NSCAI provides recommendations to overcome challenges to the digital workforce needed for national security means binned into four categories: organize, recruit, build, and employ.

During WWII, the U.S., realizing it was in a technological race with Germany and other Axis powers, recruited men and women from universities by leveraging renowned and trusted experts in their relative Science, Technology, Engineering, and Mathematics (STEM) fields. Nobel Laureates and respected terminal degree holders in sciences personally recruited seniors, by name, from Ivy League universities to join both the cryptanalysts in Washington, DC, and the Manhattan Project during WWII. Recruited members stated they joined the cause due to a sense of value in the project for national security. Members remained on the project because they worked in an environment where decision-makers valued members for their technical expertise. Decision-makers had personal relationships with those on the team due to the flattened organizational structure for the specific project. These variables were present in all three case studies: cryptanalysis during WWII, the race for the atomic bomb, and the space race.

Similarly, in all three case studies, the projects were organized under a central leadership with clearly definable goals. Cryptanalysis leaders included Alan Turing, Ann Caracristi, and William and Elizabeth Freedman; the race for the atomic bomb would not have succeeded without a decisive leader like General Leslie Groves; and the space race's visionary was the president himself. When compared to the historical case studies,

the U.S. lacks a decisive leader in the AI race. The lead U.S. DoD organization to realize the American AI Initiative Act and DoD's AI Strategy is the Joint Artificial Intelligence Center (JAIC).²⁵² Despite the JAIC's initiatives to support the Combatant Commands and the DoD Services, the JAIC does not have the resources or authorities to spearhead AI projects. The DoD solution is the creation of the Chief Digital and Artificial Intelligence Officer (CDAO). As of February 2022, the CDAO has the authority, direction, and command and control over resources and personnel to accomplish the aforementioned assigned tasks. The authorities granted to the CDAO include acquisition, special hiring and human resource support, and access to all DoD data.

The DoD solution to an inadequate structure came three years after the signing of Executive Order 13859 and five years after the PRC's declaration to achieve global leadership in AI. The NSCAI acknowledges that the DoD is trying to adopt AI solutions, but it also acknowledges that the DoD lacks a sense of urgency for the AI pivot.²⁵³ The DoD's AI Strategy lacks a sense of urgency which was a defining factor behind the success of the three historical case studies. It is yet to be seen if the newly formed CDAO will be an interlocutor and provide the decisive leadership across the DoD Services to deliver a cohesive plan. The U.S. should not wait until competition turns into conflict to realize it should have invested more heavily in AI capabilities.

Using the definition of diversity, "the inclusion of individuals representing more than one national origin, color, religion, socioeconomic stratum, and sexual orientation," all three case studies are represented because assembled teams came from many different

²⁵² "About: Joint Artificial Intelligence Center," JAIC.

²⁵³ NSCAI, *National Security Commission on Artificial Intelligence*, 77.

national origins or sexual orientations.²⁵⁴ Since WWII and the space race, social norms within the U.S. have changed. Those changes require a relook at how the DoD recruits diverse minds, diverse leaders, and diverse talent. In addition to recruiting university seniors by leveraging experts in STEM experts, the DoD should consult specifically with those STEM experts with diverse backgrounds. To specifically address diverse pools of new talent, recruiting campaigns should focus on universities known for diverse students (e.g., historically Black Colleges and Universities or universities with a large immigration population). Many of the initiators behind the atomic bomb and the race to the moon came from repressed countries during WWII. This is diversity. The U.S. Government should also consider retaining elite foreign students upon graduation or after a post-doctoral fellowship.

Finally, the DoD should cultivate respect for and promotion of technical competence. The NSCAI advocates for a National Reserve Digital Corps and an accredited, degree-granting U.S. Digital Service Academy.²⁵⁵ Lessons learned from the three case studies suggest that a separate university is not required but rather the ability to recruit and retain top talent from existing universities is attainable. Recruited members to decode adversary cryptographic machines, create a weapon of mass destruction to end WWII, and send a man to the moon indicate their leaders made them feel valued for their contributions to the projects. The DoD Services should track talent related to information warfare: computer language coding, data scientists, engineers, scientists, and AI-related skillsets even if that member is not slated to a position in which those skills are required.

²⁵⁴ “Diversity,” Dictionary.com.

²⁵⁵ NSCAI, *National Security Commission on Artificial Intelligence*, 676, 368.

Only by tracking those skillsets can leaders offer employment flexibility and remain tied to specific capabilities throughout their service.

Findings

Findings are research discoveries that may be tied to research questions. The secondary research question is what talent management programs can be employed to support the U.S. in the AI race at the strategic level. In the case of the space race, the U.S. Government passed legislation to build pools of people to cultivate the future national security workforce. During the space race, the National Defense Education Act (NDEA) provided funds at the university level but failed to realize the potential of providing funds for initiatives at the primary and secondary education levels: elementary, middle, and high school. According to the National Science and Technology Council’s Committee on STEM Education’s (CoSTEM) 5-Year STEM Education Strategic Plan, “basic STEM concepts are best learned at an early age—in elementary and secondary school—because they are the essential prerequisites for a lifetime in the workplace.”²⁵⁶ The CoSTEM further asserted that a basic understanding and comfort with STEM and STEM-enabled technology have become a prerequisite for full participation in modern society.

The PRC mandates AI education in its primary education system, starting in high school.²⁵⁷ The curriculum encompasses python programming, AI, the Internet of Things (IoT), and big data processing. To accomplish its agenda, the PRC requires AI companies

²⁵⁶ NSTC, *Charting a Course for Success*, v.

²⁵⁷ Peterson, Goode, and Gehlhaus, “AI Education in China and the United States,” 1.

to partner with schools and universities to train students.²⁵⁸ In the U.S. only 47 percent of U.S. public high schools taught computer science in 2020. The NSCAI recommends passing legislation, the National Defense Education Act II, to provide funds for STEM and foreign language initiatives during primary school and higher education. The NSCAI, recognizing the future implications of the lack of technical training for American children in the AI race with China, calls for the NDEA to fund:

- STEM and AI-focused school and after school programs,
- STEM and AI-focused summer learning programs,
- K-12 STEM teacher recruitment, training, and retention, and
- STEM scholarships, grants, and fellowships.²⁵⁹

The NSCAI also recommends that state legislatures consider making statistics in middle school and computer science principles in high school a requirement.

Additionally, the second secondary research question is how can the U.S. military overcome talent management barriers to foster the national AI strategy? the RAND Corporation's AI posture assessment titled *Department of Defense Posture for Artificial Intelligence: Assessment and Recommendations* provides recommendations from personnel in DoD, academia, and industry on how the DoD can cultivate AI talent pools. The general commonalities between the recommendations during the RAND study and the variables discovered in the case studies include an emphasis on mission, promotion of the need to solve challenging problems, respect and promotion for technical competence,

²⁵⁸ Peterson, Goode, and Gehlhaus, "AI Education in China and the United States," 1.

²⁵⁹ NSCAI, *National Security Commission on Artificial Intelligence*, 422.

and recruitment pipelines from universities. Attributes from the RAND study recommendations that are not supported within the case studies include retention incentives. Finally, two areas prominent during the historical case studies that are not present in the RAND study recommendations include clearly definable goals under centralized leadership and a sense of urgency.

Finally, the PRC's AI strategy nests within and advances the military strategy of Intelligentized Warfare, both of which are top-down driven by the president, Xi Jinping. China, aiming to offset the U.S. influence globally, is leapfrogging emerging technologies by stealing intellectual property on technical standards for AI development.²⁶⁰ The PRC is creating a new warfighting paradigm by, with, and through its AI strategy. "Advantage will be determined by the amount and quality of a military's data, the algorithms it develops, the AI-enabled networks it connects, the AI-enabled weapons it fields, and the AI-enabled operating concepts it embraces to create new ways of war."²⁶¹ The U.S. military's capability development process is too mired in bureaucracy to keep pace with China's top-down AI strategy that nests within its People's War concept. The most significant change needed today to maintain the international AI leader is digital literacy across the DoD and American youth.

Future Research

There are three topics for potential future research that stemmed from this study. The three case studies were identified based on the screening criteria: a technological

²⁶⁰ NSCAI, *National Security Commission on Artificial Intelligence*, 26.

²⁶¹ *Ibid.*, 77.

race during which the U.S. started from a position of disadvantage, the personnel in the technological race required high competence in STEM fields, and the U.S. ultimately succeeded over an adversary in the race. The three case studies, cryptanalysis during WWII, the race for the atomic bomb, and the space race, share another commonality. They all occurred during wartime. The first two studies occurred during WWII and the space race occurred during the Cold War. An area for future research would be to understand if militaries are able to radically innovate in the absence of war. The centralization of command and control and sense of urgency spurred from the nation may potentially only be galvanized during wartime. A potential research question is how can the U.S. achieve radical innovation for AI initiatives in the absence of war?

Additionally, a quantitative analysis of the AI approaches between the U.S. and the PRC does not lead to any discernable qualitative data to suggest who is the current international leader in the AI race. The RAND Corporations suggested the research question: How does China's evolving big data analytic capability rank in comparison with that of the U.S. in the military domain? This research topic requires ample time and access to classified information. There is limited publicly available information on current U.S. and People's Liberation Army AI programs. This topic would make for an excellent classified report for a limited audience.

The final topic ideal for future research centers on military culture. One potential barrier to achieving what the NSCAI recommends to employing AI experts is culture. Experts in AI, machine learning and deep learning typically have higher education in STEM degrees and are adept at coding languages (e.g., Python) and agile software and hardware development models. There should be a means to track DoD personnel with

those skills. There is currently no means to track officers for technical expertise outside of their job qualification standards throughout their careers. Those officers may or may not be interested in pursuing a command track. What are the cultural barriers to allowing officers to remain on a technical track?

Summary

This chapter provided a summary of conclusions and findings following an analysis of the talent management principles that underpin the three case studies: cryptanalysis during WWII, the race for the atomic bomb, and the space race. This chapter aimed to answer the primary research question: how can the U.S. apply lessons learned pertaining to talent management from historical technological races to maintain the competitive edge in the AI race. The secondary research questions are what talent management programs can be employed to support the U.S. in the AI race at the strategic level and how can the U.S. military overcome talent management barriers to foster the national AI strategy?

To achieve superiority in the AI race against China, the U.S. needs both a strategic initiative to build the next generation of AI-savvy Americans and a DoD-level initiative to organize a construct to drive the AI initiative with a sense of urgency. The DoD also needs to recruit university seniors by leveraging a respected member in the field of AI, ideally from within the university. Furthermore, it needs to create a centralized organizational structure with access to decision-makers across the DoD services while simultaneously fostering a flat organization for researchers, coders, and engineers. There should be one DoD leader over the AI teams who can provide direction and the sense of urgency required to stay on top.

There are several topics that emerged during the course of this study. There are three potential future topics for further research. Based on the screening criteria, the case studies: cryptanalysis during WWII, the race for the atomic bomb, and the space race, have one main similarity; they all occurred during wartime. This revelation begs the question, can militaries radically innovate in the absence of war? The second topic for future research came from the RAND Corporation which asks how does China's evolving big data analytic capability ranks in comparison with that of the U.S. in the military domain? This topic requires access to classified information and more time than was allowed during this academic year. The final topic ideal for future research centers on military culture. One potential barrier to achieving what the NSCAI recommends to employing AI experts is culture. This topic likely requires quantitative data from surveys.

There is not enough data to categorically state that China is ahead in the AI race. American ingenuity and tenacity prevailed in every case study and will again during the AI race against the pacing threat, China. It is not too late for the DoD to make radical changes to talent management to counter People's Liberation Army capabilities. Recruiting and employing technical talent is the first step to transforming the DoD's warfighting concepts in line with the information age. Providing digital literacy to all Americans during their formative years will be a more difficult challenge.

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