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AUTOMATION AND ARTIFICIAL INTELLIGENCE FOR NAVAL ISR: U.S. NAVY VS. CHINA'S NAVY

by

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13. ABSTRACT (maximum 200 words)

The U.S. Navy faces challenges as it moves toward automating the maritime battlespace and risks falling behind its rising great power competitor, the People's Liberation Army Navy (PLAN). How are the U.S. Navy and the PLAN adopting automation to improve naval intelligence, surveillance, and reconnaissance (ISR)? Results of this study indicate that the U.S. Navy is an innovator and early adopter, while the PLAN has embraced automated systems and artificial intelligence (AI) as a late modernizer, benefiting from knowledge of already relevant technologies. The U.S. Navy's Aegis and Ship Self Defense System and AI technologies enable maritime superiority; however, the PLAN is advancing in AI technologies faster than the U.S. Navy. This thesis compares the two navies in their adoption of automation and AI technologies for ISR. For purposes of this study, automation is defined as a process or specific, task-oriented system that operates without immediate human control. AI goes deeper and includes advances aimed at creating machines able to analyze, evaluate and optimize alternatives in pursuit of broader aims. I employ Everett Rogers' S-Curve model of the diffusion process as a framework for analyzing efforts to increase efficiency of naval planners and decision makers as they ponder which automated and AI technologies to adopt and how best to utilize them.

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AUTOMATION AND ARTIFICIAL INTELLIGENCE FOR NAVAL ISR: U.S. NAVY VS. CHINA'S NAVY

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ABSTRACT

The U.S. Navy faces challenges as it moves toward automating the maritime battlespace and risks falling behind its rising great power competitor, the People's Liberation Army Navy (PLAN). How are the U.S. Navy and the PLAN adopting automation to improve naval intelligence, surveillance, and reconnaissance (ISR)? Results of this study indicate that the U.S. Navy is an innovator and early adopter, while the PLAN has embraced automated systems and artificial intelligence (AI) as a late modernizer, benefiting from knowledge of already relevant technologies. The U.S. Navy's Aegis and Ship Self Defense System and AI technologies enable maritime superiority; however, the PLAN is advancing in AI technologies faster than the U.S. Navy. This thesis compares the two navies in their adoption of automation and AI technologies for ISR. For purposes of this study, automation is defined as a process or specific, task-oriented system that operates without immediate human control. AI goes deeper and includes advances aimed at creating machines able to analyze, evaluate and optimize alternatives in pursuit of broader aims. I employ Everett Rogers' S-Curve model of the diffusion process as a framework for analyzing efforts to increase efficiency of naval planners and decision makers as they ponder which automated and AI technologies to adopt and how best to utilize them.

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TABLE OF CONTENTS

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LIST OF FIGURES

LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

A2/AD	Anti-access Area Denial
ABI	Activity-Based Intelligence
AGI	Artificial General Intelligence
AI	Artificial Intelligence
AIDP	Artificial Intelligence Development Plan
AIS	Automatic Identification System
ANI	Artificial Narrow Intelligence
APT	Advanced Persistent Threat
ASCM	Anti-Ship Cruise Missile
AUV	Aerial Unmanned Vehicle
BAT	Baidu, Alibaba, Tencent
BRI	Belt and Road Initiative
CASC	China Aerospace Science and Technology Corporation
CCP	Chinese Communist Party
CEC	Circular Error Probable
CEC	Cooperative Engagement Capability
CMC	Central Military Commission
CMM	Chinese Maritime Militia
CNO	Chief of Naval Operations
COP	Common Operational Picture
COSTIND	Commission for Science, Technology and Industry for National Defense
CPC	Chinese Communist Party
CSL	Common Source Library
DARPA	Defense Advanced Projects Research Agency
DAS	Defense Acquisition System
DCGS-N	Distributed Common Ground Station-Navy
DIU	Defense Innovation Unit
DOD	Department of Defense
FONOPS	Freedom of Navigation

GANs	Generative Adversarial Networks
GLONASS	Global Navigation Satellite System
GPC	Great Power Competition
GPS	Global Positioning System
GPU	Graphic Processing Unit
GWOT	Global War on Terror
HF	High Frequency
HTI	Hardware Technology Insertion
I&W	Indications and Warning
IoT	Internet of Things
ISR	Intelligence, Surveillance, and Reconnaissance
IT	Information Technology
JAIC	Joint Artificial Intelligence Center
JCIDS	Joint Capabilities Integration and Development System
JEDI	Joint Enterprise Defense Infrastructure
JORN	Jindalee Operational Radar Network
LiDAR	Light Detection and Ranging
MABI	Maritime Activity-Based Intelligence
MARS	Machine-Assisted Analysis Rapid-Repository System
MIDB	Modernized Intelligence Database
MIIT	Ministry of Industry and Information Technology
MMSI	Maritime Mobile Service Identity
MOST	Ministry of Science and Technology
MTA	Middle-Tier Acquisition
NGA	National Geospatial-intelligence Agency
NIST	National Institute of Standards and Technology
NMCI	Navy and Marine Corps Intranet
NOSTRADAMUS	New Transhorizon Decametric System Applying Studio Methods
ODIN	Optical Dazzling Interdictor, Navy
OTH-R/B	Over-the-Horizon Radar/Backscatter
PEO	Program Executive Office
PLA GAD	People’s Liberation Army General Armaments Department,

PLAN	People's Liberation Army Navy
PLANAF	People's Liberation Army Air Force
PRC	People's Republic of China
QZSS	Quasi-Zenith Satellite System
RADAR	Radio Detection and Ranging
RIMPAC	Rim of the Pacific
SASTIND	State Administration for Science, Technology and Industry for National Defense
SCS	South China Sea
SLOC	Sea Lines of Communication
SNA	Social Network Analysis
SOF	Special Operations Forces
SSDS	Ship's Self Defense System
UAV	Unmanned Aerial Vehicle
UUV	Unmanned Underwater Vehicle

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I. INTRODUCTION

Automation and the development of artificial intelligence (AI) will influence future sea power. On July 8, 2017, President Xi Jinping and China's State Council stated their goal to build a domestic AI industry and to make the country an "innovation center for AI" by 2030.[1] On February 11, 2019, President Donald Trump signed Executive Order 13859 to maintain leadership in AI and to reflect the United States values.[2] While these strategies have been announced, the rate of adopting automation in naval affairs remains slow. In the Chief of Naval Operations' 2018 article, "A Design for Maritime Superiority," the CNO's first priority is to design a future integrated naval force structure and to "Put All Hands On Deck to make the USS *Gerald R. Ford* (CVN 78) ready as a warship as soon as practically possible."[3] Xi Jinping called upon the People's Liberation Army (PLA) to evolve to future "intelligentized warfare." The AI superpower navies compete to adopt automation and AI technologies for persistent intelligence, surveillance, and reconnaissance. This thesis compares the technological adoption of two critical automation sensors—U.S. Aegis and China's Type-348 "Dragon Eye" and how they improve naval intelligence, surveillance, and reconnaissance (ISR).

Since the Cold War, maritime superiority has come to rely on automated early warning systems from interconnected ISR platforms. Automation for maritime Indications and Warnings (I&W) was heavily embedded in conventional naval capabilities between the United States and then-Union of Soviet Socialist Republics (USSR). After the fall of the Soviet Union, China steadily rose and has been seeking the use of Artificial Intelligence (AI) to augment its military's cognitive capabilities at an ever-faster rate, especially with respect to the future of sea power. The automated communications link, called Link-11 or

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[1] Flora Sapio, Weiming Chen, and Adrian Lo, trans., *A New Generation of Artificial Intelligence Development Plan*, State Council Document [2017] No. 35 (Beijing: Chinese State Council, 2017), https://flia.org/notice-state-council-issuing-new-generation-artificial-intelligence-development-plan/.

[2] Donald J. Trump, "Maintaining American Leadership in Artificial Intelligence: Executive Order 13859," *Federal Register* 84, no. 31 (February 14, 2019): 3967–72.

[3] John Richardson, *A Design for Maritime Superiority*, Version 2.0 (Washington, DC: Department of the Navy, 2018), https://www.navy. mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf.

Link-16, between aircraft carriers, naval aircraft, and submarines allows human operators to send messages over internet computer systems instantaneously.

This study focuses on the adoption of automation-based platforms by the U.S. Navy and People's Liberation Army Navy (PLAN). Examples of naval ISR platforms include: ship automation, manned and unmanned systems, aerial reconnaissance satellites, computer systems that visualize the identification and location of naval platforms at sea. This topic is important because of three key factors: policy on rapid AI technology research and development; the return of Great Power Competition (GPC); and the need to mitigate uncertainty and enhance judgment. However, prior geopolitical incidents show that automated systems can be prone to erroneous, unstructured or unsupervised data due to device misconfiguration and human error. Receiving the right data, at the right time, at the right location is critical to understand the adoption of automation for future sea power.

The scope of this study regarding the key areas includes: strategy of automation; aids to decision-making (speed); and critical intelligence systems in space that enable automated tools to work. The overview of the impact in adopting automation is bounded by national defense and policy strategy documents by the United States and the People's Republic of China (PRC). Strategic implications of adopting critical intelligence systems will be discussed.

It is critical to adopt and harness today's automated technologies. Technological adoption of emerging technologies relies on frequent software updates and compatible hardware to successfully operate; otherwise, the system will not operate as desired or originally designed. Another way to conceptualize this process of adopting and integrating a 2020 piece of technology is to think of integrating a modern Bluetooth speaker or radio into a 1980s vehicle; possible, but the attempt to integrate incompatible software or hardware will come at a cost and can likely break down and cause incompatibility is the absence of redundant tests prior to fielding or employing an automation system or AI tool on a naval ISR platform.

A. RESEARCH QUESTION

How are the U.S. Navy and the People's Liberation Army Navy (PLAN) adopting automation to improve naval ISR with Aegis and Type 348 radar sensors for future sea power?

B. BACKGROUND

Half a century ago, General William C. Westmoreland, the U.S. Army Chief of Staff, had a vision of future warfare that rings true today. In his speech, given on October 14, 1969, to the Association of the United States Army, he stated,

> On the battlefield of the future enemy forces will be located, tracked and targeted almost instantaneously through the use of data-links, computer-assisted intelligence evaluation and automated fire control…and with surveillance devices that can continuously track the enemy, the need for large forces to fix the opposition physically will be less important.[4]

General Westmoreland encapsulated a vision of adopting constant surveillance, tracking, and targeting with computers to instantaneously track the enemy.[5]

The prominent Stanford University computer science professor, Andrew Ng, AI developer and business executive believed just as electricity transformed almost everything over a century ago, today it is hard to think of an industry that will not be touched by AI in the coming years.[6] His vision seems to be coming true, and today's software program that provides maritime domain awareness is called the Common Operating Picture (COP). The U.S. defense company Raytheon developed the COP to visually display naval air, land, and sea platforms in near-real-time. Picture dots on a screen identifying and locating naval platforms at sea based on their unique identifiers, or fingerprints, which is the manner in which GPS displays on a map. This is a form of AI application in which automation catalyzes the process and streamlines the data flow between aircraft, surface vessels, submarines, ground stations, and satellites.

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[4] Frank Barnaby, *The Automated Battlefield* (New York: The Free Press, 1986), 1.

[5] Barnaby,

[6] Shana Lynch, "Andrew Ng: Why AI is the New Electricity," Stanford News (14 March 2017), https://news.stanford.edu/thedish/2017/03/14/andrew-ng-why-ai-is-the-new-electricity/.

Since the 1950s, prominent leaders have researched and adopted pattern recognition of maritime platforms and its associated radar signature or signals in naval affairs. For naval ISR, a software program called Activity Based Intelligence (ABI) is "an analysis methodology which rapidly integrates data from multiple intelligence sources and sources around the interactions of people, events and activities, to discover relevant patterns, determine and identify change, and characterize those patterns to drive collection and create decision advantage."[7]

According to the Naval Postgraduate School (NPS) computer scientist Professor Joshua Kroll, automation is an operation of a process according to a set of established rules, which are referred to as a set of explicit and implicit specifications. These rules can be very simple or highly complex and implemented by both humans and machines in a variety of ways. These rules are implemented and coded in an "if, then" logic in a software program and then can be coupled with a mechanical function and typically in tandem with humans.[8] Automation is beneficial because it automates a task, mechanically or visually, while avoiding human weaknesses such as fatigue and inattention.

Automation and AI are imperfect and sometimes have specific errors. The systems rules or the output from the rules can be incorrect or incomplete, it can lead to a catastrophic event that would cause a stop or pause for research in automation.[9] Human error can have a big part in system error as well.

Naval sensors that automate data flow at sea have propelled naval operators and strategists to reshape the adoption of AI for the future maritime battlespace. The Department of Defense's (DOD) Artificial Intelligence strategy has accelerated "the adoption of AI and the creation of a force fit for our time."[10] Simply put, using legacy

[7] Chandler Atwood, "Activity-Based Intelligence: Revolutionizing Military Intelligence Analysis," *Joint Force Quarterly* 77 (April 2015): 24–33.

[8] Joshua Kroll, "Classifying Machines by Kinds of Learning: Automation," slide 3, https://nps.edu/web/ai-consortium/harnessing-ai-course.

[9] Kroll, slide 21.

[10] Office of Science and Technology Policy, *Summary of the 2018 White House Summit on Artificial Intelligence for American Industry* (Washington, DC: White House, 2018), 4, https://www.whitehouse.gov/wp-content/uploads/2018/05/Summary-Report-of-White-House-AI-Summit.pdf.

technologies that work is valuable, but understanding how the AI superpowers are adopting game-changing technologies is critical to improving naval ISR. A fit way to adopt automation revolves around knowledge, access, and time for relevant and accurate early warning.

The second approach is defining and understanding the literature of automation and AI, to include its perception within various sectors of society. There is not one accepted and concrete definition of automation. My approach will be to outline the standard definitions from government, military, public and private and compare their definitions to technical experts like computer scientists. When one says or hears the phrase AI various thoughts and images come to mind—images from lethal autonomous weapons destroying the adversary or killer robots to less intimidating images. The perception of AI can range from imagining sailors sitting in front of a computer screen on a ship to Apple's Siri or Amazon's Alexa technologies. The perception of automation can be as simple as an assembly line to streamlining signals automatically to control the flow of information and incorporated on a digital map to show where ships, aircraft, and submarines are located. The definition depends on whom you ask.

The third approach is analyzing automation and AI capabilities today concerning naval ISR between the AI superpowers. China's blue-water borders—also known as first, second, and third island chains and the "string of pearls" in the Indian Ocean. The fourth approach is conceptualizing and describing the design methodology for adopting automation coupled with AI emerging technologies that can be recycled, re-used, and turned around in less than six months to have the advantage of long-term strategy for adopting automation for naval ISR. This irregular method will incorporate measures of effectiveness and performance with a demanding timeline that encompasses aggressive, timely, and ethical standards.

C. RESEARCH METHODOLOGY

My thesis methodology will be to develop an adaptive model for comparatively analyzing automation and AI capabilities today between the United States Navy and China's Navy, to include their Navy's Air Force component. The goal is to produce a research methodology with precise and concise indicators and measurements for the Chairman of the Joint Chiefs to observe and absorb heuristically, to act today, and re-orient when AI software begins to outpace current technology. In Chapter II, a literature review of automation and AI are defined and technical aspects of naval ISR are necessary to discuss, conceptualize, and use a simple working definition throughout this thesis.

In addition to qualitative analysis, quantitative analysis will be conducted through both network analysis of contributing industry companies (private and public) in pursuit of developing an adoption framework for senior-level decision making and feedback systems. The purpose of a mixed methodology is to determine practices of automation for Intelligence, Surveillance, Reconnaissance. A thorough analysis of automation regarding ISR will allow for a better understanding of current trends and constraints for ISR in the maritime battlefield. It is important to note that the theory of adoption is usually based on the organization or the user; thus, I will discuss both. I will use Everett Rogers' S-curve model of the diffusion process and examine the level of adopting automation for ISR within the last 50 years.[11]

This thesis will encompass three specific automation systems that can connect to the two focus automation sensors and the cloud services both navies have adopted to store ISR data. The systems include unmanned underwater vehicles (UUVs), unmanned aerial vehicles (UAVs). In addition to the DOD enterprise-wide cloud solution, the United States has integrated the Joint Enterprise Defense Infrastructure (JEDI) Cloud Program, which can improve naval ISR support and stay abreast of China.[12] There is little known publicly available information regarding the PLAN's development plan for cloud services. However, in 2017, China's Ministry of Science and Technology, which collaborates with

[11] Mary Cain and Robert Mittman, *Diffusion of Innovation in Health Care* (Oakland, CA: California Health Care Foundation, 2002), http://kpworkforce.org/projects/include/DiffusionofInnovation.pdf.

[12] Department of Defense, *DOD Cloud Strategy* (Washington, DC: Department of Defense, 2018), https://media.defense.gov/2019/Feb/04/2002085866/-1/-1/1/DOD-CLOUD-STRATEGY.PDF.

the PLA, recruited the internet giants Baidu, Alibaba Group Holding, and Tencent Holdings—also known as BAT—for cloud computing.[13]

Everett Rogers' 1962 S-curve model of diffusion process will help better understand the current adoption methods. For example, the U.S. Defense Acquisition System (DAS) and Joint Capabilities Integration and Development System (JCIDS), and the 2020 Middle-Tier Acquisition (MTA) Pathway per DODI 5000.2 are U.S. acquisition models for technological adoption.[14] I will also use quantitative measures to relate spatial and temporal network analysis of relevant companies, private and non-profit, that can positively and negatively contribute to the adoption of automation. The purpose is to possibly reveal companies' proprietary rights and the distance or degrees of separation between them that may show weaknesses in the methodology and overall adoption process for future naval ISR.

As a case study in Chapter III, I will provide an overview of Everett's S-Curve of technological adoption and a step-by-step process to help with the process of adopting automation and AI for naval ISR. Other mentionable countries with AI strategies for adopting automated systems or AI tools to briefly be discussed in this thesis will be the United Kingdom, Russia, France, Iran, and South Korea.

D. THEORY OF TECHNOLOGICAL ADOPTION

The theory of adoption, within the context of technology, has been a focus of researchers, commercial, and industry for decades. The modern term adoption is derived from one of the Roman forms of adoption, *adoptio.* This late 15th century French and Latin phrase *adoptare* comes from *ad* meaning 'to' and *optare* meaning 'choose.'[15] Simply put,

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[13] Meng Jing and Sarah Dai, "China Recruits Baidu, Alibaba and Tencent to AI 'National Team,'" *South China Morning Post*, November 21, 2017, https://www.scmp.com/tech/china-tech/article/2120913/china-recruits-baidu-alibaba-and-tencent-ai-national-team.

[14] J. Jerry LaCamera, Jr., "Rapid Acquisition - The Challenge to Accelerate" (NDIA 2019 Spring IPM Division Meeting, Herndon, VA: National Defense Industrial Association, 2019), https://www.ndia.org/-/media/sites/ndia/divisions/ipmd/2019-04-meeting/207-middle-tier-of-acquisition-lacamera-190508215620.ashx?la=en.

[15] Frederick Mish, "Adoption," in *Merriam-Webster's Collegiate Dictionary* (Merriam-Webster Inc., 2004), 17.

one can choose an inanimate object, person, place, or thing or choose to change, or one will not change.

The S-curve of technological adoption represents a theoretical framework to help conceptualize how one or an organization can successfully or unsuccessfully adopt a technology. According to American communication theorist and sociologist Everett Rogers, the successful adoption of an innovative technology occurs in a distributed bell-curve, S-shaped, which is derived from the diffusion curve with respect to time and normality (Figure 1). The five categories of the adoption system are: (1) innovators, (2) early adopters; (3) early majority, (4) late majority, and (5) laggards.[16] Understanding of the stages within the S-shaped bell curve is important to the successful adoption of emerging technologies.

Figure 1 depicts the rate of technology adoption in the form of a horizontal and stretched "S" with adoption on the Y-axis and time on the X-axis. This means that when a technology is initially adopted, it takes years for either the technology or market conditions to adjust or develop to the point where it hits an inflection point to achieve rapid adoption.

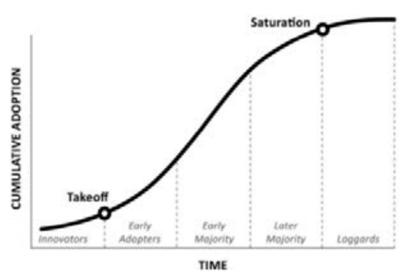

Figure 1. S-curve Model of the Diffusion Process[17]

When the market begins to become saturated, the curve flattens out and late adopters of technology are too late to adopt emerging technology and integrate into a competitive

[16] Joseph P. Schwieterman and Lauren A. Fischer, "The S-Curve of Technological Adoption: Mobile Communication Devices on Commuter Trains in the Chicago Region, 2010–2015," *Journal of Public Transportation* 20, no. 2 (2017): 1–18, https://doi.org/10.5038/2375-0901.20.2.1.

[17] Source: Schwieterman and Fischer, 3.

environment at the point of saturation, which is where the laggards reside. Naval leadership will find this useful because it means it is best to be at the inflection point of the S-curve, not at the beginning or the end of it.

As populations grow, automation and AI emerging technologies will grow. The history of the S-curve idea began in the 19th century with the motivation of knowing more about the growth of humans. Rogers' S-curve theory of adoption is based on the logistic function as a model of population growth that was first introduced by Belgian mathematician Pierre-Francois Verhulst in 1839. Verhulst related this theory to population growth and initially conceived his idea from the Englishman and political economist Thomas Malthus' "An Essay on the Principle of Population" in 1789. During this time, people worried about population growth surpassing food supply and the future of feeding the population. From 1950 to today, the population growth of the United States has grown from 330 million U.S. citizens to 1.4 billion Chinese citizens; contributing to a current population of 7.76 billion and counting.[18] The more the human population grows, the more likely the thirst for knowledge not only humans but also automation and AI. People want more automated systems and to adopt AI technologies because they are typically faster than human beings, can consume more data, provide both intelligence and surveillance, and sometimes certain technologies are simply fun to use.

An important corollary from the S-curve adoption theory is that the navies ought to build companies on technologies that have grown and experienced failures to achieve successful adoption. Some technologies include AlphaGo deep-learning system and IBM's DeepMind subsidiary of Google to play the strategy game of Go, or Weiqi. In 2016, the computer system AlphaGo defeated South Korean Grandmaster Lee Sedol.[19] For both AI superpower navies, this simulated game relates directly to how both the sensors and computer systems between USN and PLAN learn about each other on the maritime

[18] "Current Population Growth," Worldometer, https://www.worldometers.info/world-population/.

[19] David Silver et al., "A General Reinforcement Learning Algorithm That Masters Chess, Shogi, and Go Through Self-Play," *Science* 362, no. 6419 (December 2018): 140–44, https://doi.org/10.1126/science.aar6404.

battlefield. The adoption and growth of technology translate well to the life cycle pattern and measured as a cumulative growth over time.

The growth of automation technologies since the 1950s is not a surprise and is imperfect. According to Modus the S-Curve, "is derived from the law that which states that the rate of growth is proportional to both the amount of growth already accomplished and the amount of growth remaining to be accomplished."[20] The limitations are inherent to risk and uncertainty over time. Like the life cycle—periods of birth, growth, puberty or maturity, and death—the S-curve stages serve as the key mechanism to decelerate, accelerate, shift gears, or stop completely and start fresh. Not every specific naval sensor or computer system designed for ISR is going to achieve perfect knowledge of the maritime battlefield.

This observation is recognized and utilized in the commercial sector. Former CEO of Google and board member of the DOD Advisory board Eric Schmidt believes the problems are straightforward. He believes computer vision is easily understood if we build reliable systems in which we understand failure modes and error rates.[21] Receiving, analyzing, and disseminating information and intelligence via Aegis with computer systems connected to sensors with a time gap creates a recognized frustration among the younger operators who envision computer systems and AI applications, like a high-resolution video game, is a weakness in adopting automation.

Human beings use automation software applications to solve problems. It is important to understand that automation is currently not capable of making intelligence assessments. AI simulates cognitive functions of the human brain and computer vision displaying data. In the United States Navy, the human operators behind the machine use

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[20] David Lindgren, "Global Remittances and Space-Based Cryptocurrencies: A Transformational Opportunity for the Post-2030 Agenda," in *Post 2030-Agenda and the Role of Space*, ed. Annette Froehlich (Cham, Switzerland: Springer International Publishing, 2018), 79, https://www.springer.com/gp/book/9783319789538.

[21] Paul Scharre, Anthony Cho, and Eric Schmidt, "Eric Schmidt Keynote Address at the Center for a New American Security Artificial Intelligence and Global Security Summit" (Washington, DC: Center for a New American Security, November 17, 2017).

the rule-based automation system which displays radar signals. The data at rest—the data in the computer not being used or manipulated—is limited to the amount of data input.

Change in adoption theory is inescapable. Similar to American historian Elting Morison's research and reflection process, much of the adoption of automation centers around four distinct parts: the initial condition "at the point of origin of any mechanical change; the character of the primary agents of change; the nature of those resistant to change; and the means to facilitate accommodation to the changes introduced."[22] Without understanding and enduring these parts, one cannot rise above the threshold of existing bodies of knowledge.

In 2020, we are in another time of tremendous technological development and return of GPC by which maintaining future sea power depends on superiority in the fourth dimension of cyberspace. Russia's President Vladimir Putin once said, "Artificial intelligence is the future, not only for Russia but for all humankind. It comes with colossal opportunities, but also threats that are difficult to predict. Whoever becomes the leader in this sphere will become the ruler of the world,"[23] Automating simple tasks and adopting AI tools, even with legacy systems, demands a change in today's GPC and national security.

[22] Elting Morrison, *Men, Machines, and Modern Times* (Cambridge, MA: MIT Press, 1966), 7.

[23] "'Whoever Leads in AI Will Rule the World': Putin to Russian Children on Knowledge Day," RT World News, September 1, 2017, https://www.rt.com/news/401731-ai-rule-world-putin/..

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II. LITERATURE REVIEW

The U.S. naval intelligence team on the carrier is searching for the last location of an unknown, Chinese Kilo submarine. The radar returns visualized as automated dots appear on shipborne computer screens which show two Chinese warships. There is some ambiguity in their identification, current time, and location. The operator watch team on the aircraft carrier using AI software sees automated dots in motion appear with unique identifiers of Chinese fighter aircraft taking off from Hainan Island in the South China Sea (SCS). Chinese fighter aircraft have a radar signature, such as identification, and then U.S. Navy ISR collection platforms and sensors can collect the data to provide situational awareness. This technological exchange of information is like how commercial aircraft can be identified or identify other aircraft while flying. A naval intelligence team of six notices the automation and do what is necessary—notifies the watch and immediately provide timely, relevant, accurate indications and warning (I&W). The Carrier Strike Group (CSG) decision-makers operating in the SCS are depending on an early warning. One of several computer screens using automation tools, fueled by algorithms or software, shows pixilated dots on a computer screen with a geographic map of SCS as the background. The tactical action officer, Surface Warfare Officers, and the team of intelligence officers and specialists track dot(s) on computer screens. The dot represents a Chinese destroyer, under the command of the People's Liberation Army Navy (PLAN), approaching USS *Wayne E. Meyer* (DDG-108) conducting Freedom of Navigation Operations (FONOPS). Automation tools, powered by AI algorithms, provide precise time, distance, course, and speed to allow situational awareness and early warning to react.

The aforementioned vignette is representative of historical events in SCS that have sent a clear strategic message of mutual power projection and presence between the United States and China. Automation expedites maritime ISR and naval encounters at sea between foreign navies for situational awareness for both adversarial and commercial platforms. In 2017, the U.S. Navy conducted at least six routine FONOPS, according to the Defense

Department.[24] Further, National Geospatial-Intelligence Agency (NGA) collects and uses data for Maritime Activity-based Intelligence (MABI) software, which provides: geo reference time and location similar to Google Maps; sequence and data neutrality for unbiased data; and, integration before exploitation.[25] In September 2019, *USS Wayne E. Meyer*—named after the father of the Aegis combat system—conducted FONOPS near the Paracel Islands (located in the northern part of South China Sea). In response, Chinese military vessels and aircraft attempted to deter the U.S. warship from sailing near the Chinese-claimed islands.[26]

The purpose of this chapter is to gain a better understanding of automation and AI. This will be organized through five subsections: (1) South China Sea historical vignette; (2) a literature review on prominent leaders from America and from China who are experts in the field of AI and automation; (3) definitions of automation and AI; propose my working definition of automation and AI-based on existing literature, publications, and doctrine between technical, government, and public experts; (4) conceptualize automation and, (4) a succinct technical overview understanding of naval ISR about the two sensors.

A. AI POLICY AND STRATEGY DOCUMENTS

For foundational purposes, I cite four national strategy and policy documents: Department of Defense Directive (DODD)[27]; Joint Publication 1-02[28] and 2–01[29]; and, two

[24] Caitlin Doornbos, "Freedom-of-Navigation Ops Will Not Dent Beijing's South China Sea Claims, Experts Say," *Stars and Stripes*, April 4, 2019, https://www.stripes.com/news/pacific/freedom-of-navigation-ops-will-not-dent-beijing-s-south-china-sea-claims-experts-say-1.575609.

[25] Patrick Biltgen and Stephen Ryan, *Activity-Based Intelligence: Principles and Applications* (Boston: Artech House, 2016), xx.

[26] Jesse Johnson, "U.S. Warship Challenges Chinese Claims in Disputed South China Sea," *Japan Times*, September 14, 2019, https://www.japantimes.co.jp/news/2019/09/14/asia-pacific/u-s-warship-challenges-chinese-claims-disputed-south-china-sea/#.Xhd7aMhKj_M.

[27] Department of Defense, *Autonomy in Weapon Systems*, DOD Directive 3000.9 (Washington, DC: Department of Defense, 2012), https://www.hsdl.org/?abstract&did=726163.

[28] Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms*, Joint Pub. 1–02 (Washington, DC: Joint Chiefs of Staff, 2016), https://fas.org/irp/doddir/dod/jp1_02.pdf.

[29] Joint Chiefs of Staff, *Joint Intelligence Support to Military Operations*, Joint Pub 2–01 (Washington, DC: Joint Chiefs of Staff, 1996), http:// www.hsdl.org/?view&did=3737.

summaries of AI Strategy by the United States[30] and China.[31] The first is DODD 3000.9, which "establishes DOD policy and assigns responsibilities for the development and use of autonomous and semi-autonomous functions in ISR systems, including manned and unmanned platforms."[32] The second is JP 2-01 (Joint and National Intelligence Support to Military Operations), specifically the ISR section on integrated operations and intelligence activities and synchronization of OPINTEL and ISR automated visualization (of collected data).[33] The third is the 2018 Department of Defense Summary of the 2018 Department Of Defense Artificial Intelligence Strategy: Harnessing AI to Advance Our Security and Prosperity, which discusses harnessing strategic and focused deliverable AI.[34] The fourth is China's 2017 State Council "New Generation Artificial Intelligence Development Plan" (AIDP), which aptly focuses on science, technology, industry, market, and societal perception.[35] These policy documents are the most important driving sources for AI strategy and development.

Existing literature on automation for sea power suggests that time, demand, and resources are critical factors in succeeding in adopting AI. According to the Fiscal Year 2020 DOD Defense Budget, $927 million is dedicated to expanding AI to expand military advantage with the Joint Artificial Intelligence Center (JAIC) and Advanced Image Recognition (Project Maven) and $3.7 billion for autonomous and unmanned vehicles.[36] The

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

31 Sapio, Chen, and Lo, *A New Generation of Artificial Intelligence Development Plan*.

32 Department of Defense, *Autonomy in Weapon Systems*.

33 Joint Chiefs of Staff, *Joint Intelligence Support to Military Operations*.

34 Department of Defense, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*.

35 State Council, "New Generation Artificial Intelligence Development Plan [国务院关于印发新一代人工智能发展规划的通知]," July 8, 2017, ttp://www.gov.cn/zhengce/content/2017- 07/20/ content_5211996.htm.

36 Office of Undersecretary of Defense (Comptroller)/Chief Financial Officer, *Defense Budget Overview: United States Department of Defense Fiscal Year 2020 Budget Request* (Washington, DC: Department of Defense, 2019), https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/ fy2020_Budget_Request_Overview_Book.pdf.

most recent 2020 White House budget document regarding the non-defense AI agencies listed a $1,291,000,000 FY20 request compared to the FY19 estimate of $1,248,000,000.

However, both commercial and private industries are leading innovation in emerging technologies. The Trump administration has identified non-defense AI spending as a supplement to the president's FY 2020 budget request. According to U.S. Chief Technology Officer Michael Kratsios, the budget released in September 2019 shows $654.4 million dedicated to the U.S. government's non-defense spending by agencies related to AI.[37] This supplemental document aligns with Executive Order 13589, signed by President Donald Trump in February 2019, specifically to maintain leadership in AI in the federal research and development sector.

The two institutions most relevant to AI for naval ISR spending are Defense Advanced Research Projects Agency (DARPA) and Intelligence Advanced Research Projects Activity (IARPA). According to the White House, IARPA oversees several AI projects: developing AI models for cybersecurity, analyze autonomous systems policies, improve the interface between humans and intelligent systems, and develop counter AI tools (i.e., TrojAI). DARPA oversees next-generation AI and "explainable AI," programs such as developing machine learning techniques and enable human users to understand, trust and manage AI partners.[38] However, DARPA budget figures for AI research and development are not publicly available.

The strategies, policies, and budget for automation are the fundamental basis for gaining a shared sense of understanding of automation and AI. Next, this literature review will cover the history of thought leaders, a variety of definitions, and my working definition to better grasp both terminologies and ultimately, improve the adoption process.

B. PROMINENT LEADERS OF AUTOMATION

In 1969, then-U.S. Army Chief of Staff General William C. Westmoreland stated, "On the battlefield of the future enemy forces will be located, tracked and targeted almost

[37] National Security & Technology Council, 11.

[38] National Security & Technology Council, 15.

instantaneously using data-links, computer-assisted intelligence evaluation, and automated fire control. With first-round kill probabilities approaching certainty, and with surveillance devices that can continuously track the enemy, the need for large forces to fix the opposition physically will be less important."[39] His outspoken vision resonates today with 24-hour real- and near-real-time ISR.[40] Because of General Westmoreland's vision, automation has long been a focus of the United States military to rapidly provide early I&W against adversaries at sea.

1. History of Automation from Prominent American Leaders

Stanford computer science professor and recipient of the Association for Computing Machinery Turing Award Edward Albert "Ed" Feigenbaum did much to pioneer AI.[41] In the 1980s, he defined AI research as the "part of Computer Science that investigates symbolic reasoning processes and the representation of symbolic knowledge for use in inference."[42] Feigenbaum's concept was an important contribution to the future success of AI. Feigenbaum describes AI as a process to simply start and continuously research and develop AI and then to think about how to best represent that knowledge. His definition describes the best way to represent such knowledge is through a symbolic way such that the target practitioner, or operator, can digest and use the technology.

Feigenbaum's strategic design centers around a direct partnership between three main entities for the efficient and effective flow of information. He emphasizes dialogue between the expert and the knowledge engineer directly because this process marries expert designers, knowledge engineers, and the user or operator. As a result, the early exchange of

[39] Frank Barnaby, *The Automated Battlefield* (New York: The Free Press, 1986).

[40] The term "real-time" is defined as current time and "near-real-time" are naval platforms that naval operators manually add to an automation situational awareness tool; also known as Common Operational Picture (COP).

[41] Nils J. Nilsson, "Edward A ('Ed') Feigenbaum: United States - 1994," Association for Computing Machinery, A.M. Turing Award, 2019, https://amturing.acm.org/award_winners/feigenbaum_4167235.cfm.

[42] Edward A. Feigenbaum, "Expert Systems in the 1980s" (Stanford, CA: Stanford University, 1980), https://stacks.stanford.edu/file/druid:vf069sz9374/vf069sz9374.pdf.

information facilitates an environment to accomplish a specific task or goal at hand.[43] Sparking an early and continuous dialogue between the three main entities is crucial in contributing to the success of AI.

From a technical perspective, the goal of the "expert system" is to design and write a computer science program that will automate the problem faster. According to computer scientist and founder of the *International Journal on Artificial Intelligence Tools* Nikolas Bourbakis, AI helps achieve a high level of performance for difficult problems and difficult for a human to solve on his or her own.[44] Therefore, expert systems produce an effective and direct flow of information logically between the three main entities. The architecture of this expert system, however, limits the relevant and accurate information. This is where the knowledge engineer filters out irrelevant information and methods or mechanisms within the field of AI.

Technological innovators believed after the industrial age and information age comes adopting the automation age. In the year 2000, Admiral William A. Owens' *Lifting the Fog of War*, expressed that we live in the fourth "Age of Automation"[45] He believed the most notorious example of new technology was Adolf Hitler's 1940s blitzkrieg, or "lightning war," because its purpose was to bring about a swift victory and combine the use of radio communication, air and land support, and tank division. The users in the "lightning war" were operators with critical information that had to be shared with both the knowledge engineer and experts to adopt the automated system on the land battlefield. The concept and the testing of automated systems on land helped advance the adoption of automation.

British Army officer, military historian, and strategist J. F. C. Fuller writes about the origins of flight, satellite connectivity, and wireless capability advancing the "Age of Automation." He first describes the first flight on December 17, 1903, at Kill Devil Hill, Kitty Hawk, North Carolina, where two brothers, Orville and Wilbur Wright, flew a power-

[43] Barnaby, *The Automated Battlefield*.

[44] Nikolas G. Bourbakis, ed., *Artificial Intelligence and Automation* (Hackensack, NJ: World Scientific Publishing, 1998), 210, https://doi.org/10.1142/3079.

[45] William A. Owens, *Lifting the Fog of War* (Baltimore: Johns Hopkins University Press, 2001), 80.

driven airplane for twelve seconds and the best flight was in 69 seconds. Fuller writes about the second invention encompassing the space domain in 1887 when a German Physicist Heinrich Rudolf Hertz was the first man to conclusively prove the existence of the electromagnetic wave where an electrical spark propagates into space. He then describes the third invention of wireless capability. Later in 1897, an Italian electrical engineer Guglielmo Marconi invented a device to detect said electric spark or waves and wirelessly transmitted a message over 3,000 miles in 1901.[46] These scientific inventions are the bedrocks that revolutionized both military and naval affairs to adopt automated systems.

Prominent scientists and theorists inspired the U.S. military to take advantage of flight, satellite connectivity, and wireless capability for future naval ISR capabilities. For example, then-CNO Adm. George W. Anderson, Jr. oversaw the first U.S. nuclear-powered aircraft carriers *USS Enterprise* (CVAN-65). Automation on nuclear-powered carriers today could not evolve if it were not for the first aircraft carrier. In addition to advancements in naval aircraft carriers, Research and Development Corporation (RAND) funded three Logic Theorists—Allen Newell, Cliff Shaw, and Herbert Simon—to present a computer problem solving-program.[47] In 1956, Stanford professor John McCarthy and Massachusetts Institute of Technology (MIT) professor Marvin Minsky hosted the Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI).[48] The popular desire for AI in both the military and academia realms increased the demand for adopting AI.

However, overhyped emerging technologies and huge expenses hindered the advancements of automation. Computer scientists Peter Norvig and Stuart Russell wrote that the AI headline news in the 1950s typically read "Electronic Super-Brains" and "Faster Than Einstein," but the hype in media was only part of the incubation for adopting automation.[49]

[46] John Frederick Fuller, *Armament and History: The Influence of Armament on History from the Dawn of Classical Warfare to the End of the Second World War* (Cambridge, MA: Da Capo Press, 1998).

[47] Rockwell Anyoha, "The History of Artificial Intelligence," *SITN Blog* (blog), August 28, 2017, http://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/.

[48] John McCarthy et al., "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence" (Hanover, NH: Dartmouth College, August 31, 1955), http://jmc.stanford.edu/articles/dartmouth.html..

[49] Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (Englewood Cliffs, NJ: Prentice Hall, 1995), 4.

Both Norvig and Russell understood that the demand was present, but two issues prevented the adoption of automation or AI. In addition to a high price, they stated that computer processors could not store or "remember" input data, and computers cost over $200,000 per computer and simply too costly of an investment.[50]

2. History of Automation by Chinese Prominent Leaders

The vision of automation and AI to modernize the Chinese Navy from 1958 to 1962 began with the Great Leap Forward, shifting its organizational structure. The leap represented a catalyst because of the Sin-Soviet dispute; abandoned the previous balanced development strategy; and, gave birth to a new social organization called the people's commune.[51] Under the Communist Party of China (CPC), then-Chairman Mao Tse-tung had the vision to reconstruct the country from an agrarian economy to a communist society to leap ahead of competing neighbors and adversaries. The Chinese sought to change its navies like that of the Soviet Gorshkovian doctrinal changes which were then echoed by Admiral Liu Huaqing.[52] Chinese naval thought leaders began to appreciate and take advantage of the value of their navy for sea power and maritime domain awareness.

Two prominent PLAN admirals, Liu Huaqing and his successor Zhang Lianzhong, contributed to the future of China's naval force projection and rapid response capabilities, according to James Lilley, former U.S. ambassador to China in 1989, and James Shambaugh, George Washington University Professor on China policy.[53] As the Commander of PLAN from 1982 to 1988 and then-Vice Chairman of the Military Commission, Admiral Huaqing designed a strategy to promote the PRC's 1982 naval maritime plan to move from coastal

[50] Robert Garner, "Early Popular Computers, 1950 - 1970," Engineering and Technology History Wiki, January 9, 2015, https://ethw.org/Early_Popular_Computers,_1950_-_1970.

[51] Roderick MacFarquhar, *The Origins of the Cultural Revolution: Volume II, the Great Leap Forward 1958–1960*, 2nd ed. (New York: Columbia University Press, 1983).

[52] Geoffrey Till, *Seapower: A Guide for the Twenty-First Century*, 2nd ed. (Abingdon, UK: Routledge, 2009).

[53] James Lilley and David L. Shambaugh, *China's Military Faces the Future* (Abingdon, UK: Routledge, 1999), 27.

defense toward a blue-water capability in incremental 10-year plans.[54] This vision led to increasing demands for advanced technology in a three stage strategy for maritime defense.

In *Artificial Intelligence and Automation* by Nikolas Bourbakis, PRC Xi'an Jiaotong University Professor Hongyi Wang discusses issues about AI related to organic systems to knowledge development issues and unifying the gap between computers and human brains.[55] This definition paves a pathway that starts knowing what the problem(s) are, drives through development, requires structuring and/or visualization, and unification between a human being and the computer. In a way, his point describes a marriage between two separate entities designed to bring forth increased intelligence to help solve problems faster and together.

PLAN seeks to end U.S. maritime superiority across both the Pacific and the Indian Oceans by technologically advancing its fleet. According to the Office of Naval Intelligence analysts, Adm. Huaqing, a member of the Chinese Academy of Science, assisted then-President Deng Xiaoping and the Chinese Communist Party's (CCP) Central committee's Politburo to help shape the future of PLA.[56] In 1988, Admiral Lianzhong designed "sea-denial" out to the first chain of islands to about 150 miles from the mainland, otherwise known as access and area denial (A2/AD). This defense strategy is known as "defense in depth" and its purpose is to surveil and defense its sea borders with conventional and nuclear submarines, long-range aircraft, and surface vessels.[57] China's methodology for achieving maritime superiority receives tremendous support from its thought leaders in academic universities that brought forth its naval ISR vision to fruition.

In contrast to Feigenbaum's "Expert Systems," China's approach heavily weighs the initial development stage. Kai-fu Lee is very authoritative for this topic in technology

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[54] Andrew Erickson and Gabe Collins, "China's Real Blue Navy," *The Diplomat*, August 30, 2012, https://thediplomat.com/2012/08/chinas-not-so-scary-navy/.

[55] Bourbakis, *Artificial Intelligence and Automation*, 9.

[56] Office of Naval Intelligence, *China's Navy 2007* (Washington, DC: Office of Naval Intelligence, 2007), 11–14, https://fas.org/irp/agency/oni/chinanavy2007.pdf.

[57] Till, *Seapower*, 153.

between China and the United States.[58] He is the chairman and COE of Sinovation Ventures, a Chinese-based technology-focused investment firm, and has held vital positions in Apple, Silicon Graphics, Microsoft, and Google where he was president of Google China. In his book "AI Superpowers," he estimates automation will decimate up to 40–50 percent of jobs worldwide.[59] This is the trade-off in adopting more automated systems and AI technologies that decision-makers can consider in the adoption process.

In July 2017, the State Council of China released the "New Generation Artificial Intelligence Development Plan," which is a strategy to build a domestic AI industry worth nearly U.S. $150 billion and to become the leading AI power by 2030.[60] AI Industry Development Alliance, a co-sponsored alliance between more than 200 enterprises and agencies nationwide to develop China's AI industry. The 2016–2018 Chinese Three-Year Guidance for Internet Plus Artificial Intelligence Plan was written for socioeconomic development. Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018–2020) reinforces the AI development plans previously mentioned.

In the adoption process, understanding and discussing the vision set by naval leadership can help decision-makers who are in the process of adopting automation and AI in the coming decades. The U.S. Navy leverages major university researchers and computer scientists to adopt automation and AI. The PLAN's Three- or Five-Year development plans and AI strategy lay out the adoption process and executing each step in a rapid pace. The next section will cover the various definitions of automation and AI.

C. ON DEFINING AUTOMATION AND AI

This section will explore the evolution of automation and AI over the last 70 years. The purpose of discussing the definitions of automation is to shed light on the contrasting definitions, derived from both the U.S. and China's AI strategy documents to gain a better

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[58] Kai-fu Lee, *AI Superpowers: China, Silicon Valley, and the New World Order* (Boston: Houghton Mifflin Harcourt, 2018).

[59] Lee.

[60] Sapio, Chen, and Lo, *A New Generation of Artificial Intelligence Development Plan*.

understanding of the history of adopting automation of naval ISR and the current adoption progress.

Humankind derives from homo sapiens—wise man—because our cognitive capabilities are important in our everyday lives when making decisions. Human beings in the private, public, and commercial centers have constantly developed new superior tools and technologies to solve a problem faster; they create it and then the Navy acquires and applies the tools.

There is no worldwide accepted definition of AI, according to prominent AI researchers Kirsch, Allen, Hearst and Kirsh, Brachman, Nilsson, Bhatnagar, and Monett, and Lewis.[61] Depending on whom one asks from different communities, categorizing the terms "AI" and automation and learning the levels of complexity will help design the fittest definition for the current strategies between the two superpowers.

1. Working Definitions of Automation and AI

The following table depicts my working definition of automation versus AI drawn from the elements of automation and AI experts since 1950. Based on the evidence from a diverse group of researchers and fields of study, automation and AI can be simple, complex, or extraordinary, ranging from prespecified to unpredictable and manual to automatic. Simply put, both the tools and techniques solve problems and attain goals. My working definitions are based on lists of definitions written by government personnel, academic researchers, and computer scientists (see Table 1).

Table 1. Working Definitions for Automation and AI

Automation	**Artificial Intelligence**
Automation is a technique of making a computer, a process, or a system operate automatically by a mechanical or electronic device that takes place of the human labor to accomplish a task or goal.	AI is an evolutionary and combined field of study to create intelligent machines through a set of established rules in the form of algorithms to achieve a specific goal or set of goals.

[61] Pei Wang, "On Defining Artificial Intelligence," *Journal of Artificial General Intelligence* 10, no. 2 (2019): 1–37, https://doi.org/10.2478/jagi-2019-0002.

AI has become an increasingly popular topic, but the term AI is something of a misnomer, according to NPS Professor John Arquilla.[62] Computer software and algorithms are only productive and made "intelligent" when created, typed, and used by human beings. By software automation, we "rely on computer systems as much as possible in software development, in other words, to generate programs from information requirements automatically."[63] To simply put, without its creator, the computer itself or the data at rest cannot produce intelligence on its own in a way that human beings can, nor can it empathize or have a beating heart like a human being. Although a well-defined and acceptable definition differs and goals to achieving computer systems with these human-like characteristics and capabilities, automation is still not intelligent independent of the human being. However, to remain competitive and gain or maintain knowledge on the maritime battlefield, naval ISR is worth the effort to give this topic the time and space.

2. List of AI Definitions and Strategies

Table 2 shows a diverse list of definitions by technical experts compared to government and public experts on automation and the following table on AI. The International Society of Automation (ISA), a non-profit professional association founded in 1945 defines automation as "the creation and application of technology to monitor and control the production and delivery of products and services."[64] In "Artificial Intelligence: A Modern Approach," UC Berkeley professors Stuart Russell and Peter Norvig define AI as "the designing and building of intelligent agents that receive percepts from the environment and take actions that affect that environment."[65] This definition by its nature builds upon an idea similar to the human mind at first glance; however, unites the subfields of the following computer science skills: machine learning, pattern recognition, computer vision, speech recognition, etc.

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[62] John Arquilla, "The New Face of Battle" (lecture, Naval Postgraduate School, Monterey, CA, December 4, 2019).

[63] Bourbakis, *Artificial Intelligence and Automation*, 289.

[64] "What Is Automation?," International Society of Automation, accessed January 28, 2020, https://www.isa.org/about-isa/what-is-automation/.

[65] Russell and Norvig, *Artificial Intelligence:*

Tables 2 shows a list of definitions of automation and AI between technical experts and military and government professionals. Table 3 displays the United States AI strategy and PRC's development plan.

Table 2. Definitions by Technical and Government/Public Officials

Technical Experts: Computer Scientists, Data Scientists
"The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."[66]
"By 'general intelligent action' we wish to indicate the same scope of intelligence as we see in human action: that in any real situation behavior appropriate to the ends of the system and adaptive to the demands of the environment can occur, within some limits of speed and complexity."[67]
"AI is concerned with methods of achieving goals in situations in which the information available has a certain complex character. The methods that have to be used are related to the problem presented by the situation and are similar whether the problem solver is human, a Martian, or a computer program."[68]
"A useful definition of intelligence… should include both biological and machine embodiments, and these should span an intellectual range from that of an insect to that of an Einstein, from that of a thermostat to that of the most sophisticated computer system that could ever be built."[69]
"AI becomes a science (1987—present)" (Russell and Norvig, 2002), which was later changed to "AI adopts the scientific method (1987—present)" (Russell and Norvig, 2010), because "It is now more common to build on existing theories than to propose brand-new ones, to base claims on rigorous theorems or hard experimental evidence rather than on intuition, and to show relevance to real-world applications rather than toy examples."[70]
"I suggest we replace the Turing test by something I will call the 'employment test.' To pass the employment test, AI programs must be able to perform the jobs ordinarily performed by humans. Progress toward human-level AI could then be measured by the fraction of these jobs that can be acceptably performed by machines."[71]
"The creation and application of technology to monitor and control the production and delivery of products and services."[72]

66 McCarthy et al., "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence."

67 Allen Newell and Herb Simon, "Computer Science as Empirical Inquiry: Symbols and Search," *Communications of the ACM* 19, no. 3 (March 1976): 116, https://doi.org/10.1145/360018.360022.

68 John McCarthy, *Formalizing Common Sense: Papers*, ed. Vladimir Lifschitz (New York: Ablex Publishing Corporation, 1990), 246.

69 James S. Albus, "Outline for a Theory of Intelligence," *IEEE Transactions on Systems, Man and Cybernetics* 21, no. 3 (June 1991): 474, https://doi.org/10.1109/21.97471.

70 Wang, "On Defining Artificial Intelligence," 14.

71 Nils J. Nilsson, "Edward A ('Ed') Feigenbaum: United States - 1994," Association for Computing Machinery, A.M. Turing Award, 2019, https://amturing.acm.org/award_winners/feigenbaum_4167235.cfm.

72 Peter Mendel et al., "Interventions in Organizational and Community Context: A Framework for Building Evidence on Dissemination and Implementation in Health Services Research," *Administration and Policy in Mental Health* 35, no. 1–2 (March 2008): 21–37, https://doi.org/10.1007/s10488-007-0144-9.

Government/Public: Military, Private, Public, Commercial
"The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."[73]
"A branch of computer science dealing with the simulation of intelligent behavior in computers. The capability of a machine to imitate intelligent human behavior."[74]
"Artificial intelligence (AI), the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings."[75]
"The field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem solving, and pattern recognition."[76]
"'Create smarter, more useful technology and help as many people as possible' 'from translations to healthcare to making our smartphones even smarter.'"[77]
"The ability of a machine communicating using natural language over a teletype to fool a person into believing it was a human. 'AGI' or 'artificial general intelligence' extends this idea to require machines to do everything that humans can do, such as understand images, navigate a robot, recognize and respond appropriately to facial expressions, distinguish music genres, and so on."[78]
"It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."[79]
"Advancing the file of machine intelligence and are creating new technologies to give people better ways to communicate."[80]
"Fundamentally exists to substitute work activities undertaken by human labor with work done by machines, with the aim of increasing quality and quantity of output at a reduced unit cost."[81]

[73] "Artificial Intelligence," in *Oxford Reference*, accessed June 8, 2020, https://www.oxfordreference.com/view/10.1093/oi/authority.20110803095426960.

[74] Merriam-Webster Inc., "Artificial Intelligence," accessed February 12, 2020, https://www.merriam-webster.com/dictionary/artificial%20intelligence.

[75] B.J. Copeland, "Artificial Intelligence," in *Encyclopedia Britannica*, March 24, 2020, https://www.britannica.com/technology/artificial-intelligence.

[76] "What Is Artificial Intelligent?," Amazon Web Services, accessed June 5, 2020, https://aws.amazon.com/machine-learning/what-is-ai/.

[77] Bernard Marr, "The Key Definitions of Artificial Intelligence (AI) That Explain Its Importance," *Forbes*, February 14, 2018, https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/#532664514f5d.

[78] This quote is attributed to Dr. Matt Mahoney, a data compression expert; Daniel Faggella, "What Is Artificial Intelligence? An Informed Definition," *Emerj*, December 21, 2018, https://emerj.com/ai-glossary-terms/what-is-artificial-intelligence-an-informed-definition/.

[79] Maki K. Habib, *Revolutionizing Education in the Age of AI and Machine Learning* (Hershey, PA: IGI Global, 2019), 6.

[80] Marr, "The Key Definitions of Artificial Intelligence (AI) That Explain Its Importance."

[81] Mark Muro, Robert Maxim, and Jacob Whiton, *Automation and Artificial Intelligence: How Machines Are Changing People and Places?* (Washington, DC: Brookings Institute: Metropolitan Policy Program, 2019), https://www.brookings.edu/wp-content/uploads/2019/01/2019.01_BrookingsMetro_Automation-AI_Report_Muro-Maxim-Whiton-FINAL-version.pdf.

Government/Public: Military, Private, Public, Commercial
"Artificial intelligence (AI) refers to the ability of a computer or a computer-enabled robotic system to process information and produce outcomes in a manner similar to the thought process of humans in learning, decision making and solving problems."[82]
(1) "Any artificial system that performs tasks under varying and unpredictable circumstances without significant human oversight, or that can learn from experience and improve performance when exposed to data. (2) An artificial system developed in computer software, physical hardware, or other context that involves that solves tasks requiring human-like-perception, cognition, planning, learning, communication, or physical action (3) An artificial system designed to think or act like a human, including cognitive architectures and neural networks. (4) A Set of techniques, including machine learning, that is designed to approximate a cognitive task (5) An artificial system designed to act rationally, including an intelligent software agent or embodied robot that achieves goals using perception, planning, reasoning, learning, communicating, decision-making, and acting."[83]

Table 3. U.S. and PRC AI Strategies

United States	People's Republic of China
"Artificial intelligence (AI) is one such technological advance. AI refers to the ability of machines to perform tasks that normally require human intelligence—for example, recognizing patterns, learning from experience, drawing conclusions, making predictions, or taking action—whether digitally or as the smart software behind autonomous physical systems."[84]	"Artificial intelligence has become the new focus of international competition. Artificial intelligence is thought to be the strategic technology leading the future, the world's major developed countries regard the development of artificial intelligence as the major strategy to increase national competitiveness and enhance national security, therefore they intensify the introduction of plans."[85]
	"AI is already a popular concept, but there is not yet a universally accepted definition for it. The traditional approach to AI development is to study how human intelligence occurs and create machines that imitate human thinking and behavior."[86]

[82] Mike Quindazzi, "Artificial Intelligence and Robotics 2017: Leveraging Artificial Intelligence and Robotics for Sustainable Growth," *ASSOCHAM India*, April 4, 2017, 7, https://www.slideshare.net/MikeQuihumndazzi/artificial-intelligence-and-robotics-in-2017.

[83] "National Security Commission on Artificial Intelligence Act of 2018," § S. 2806 (2018), 2, https://www.congress.gov/115/bills/s2806/BILLS-115s2806is.pdf.

[84] Department of Defense, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*.

[85] State Council, "New Generation Artificial Intelligence Development Plan [国务院关于印发新一代人工智能发展规划的通知]," July 8, 2017, ttp://www.gov.cn/zhengce/content/2017- 07/20/content_5211996.htm.

[86] China Institute for Science and Technology Policy, *China AI Development Report 2018* (Beijing: China Institute for Science and Technology Policy at Tsinghua University, 2018), 9, http://www.sppm.tsinghua.edu.cn/eWebEditor/UploadFile/China_AI_development_report_2018.pdf.

The technical experts divide the definitions between theory and practice which have evolved since the 1950s. Computer scientists McCarthy, Newell, Simon, and Minsky believe in computers achieving goals to solve a specific problem that a machine can simulate in each environment.[87] The government, private, public, and commercial trends toward productivity. This study shows that both technical experts and government researchers are more concerned about automation and AI performing a task to solve a problem expeditiously. AI experts and organizations such as Matt Mahoney, Facebook, Congress specifically point out the desire for AI to imitate human intelligence for better communication.

In recent years, a revitalization of AI has erupted, partly due to the hope of successful new techniques such as machine learning and deep learning. Various categories of AI include Artificial Narrow Intelligence (ANI),[88] Artificial General Intelligence (AGI), and Artificial Superintelligence (ASI).[89] Technical experts develop ANI, or "weak" intelligence, to perform a singular task such as human beings playing chess online, marketing trends, autonomous cars, and speech and pattern recognition. These new labels show that the meaning and definition of "AI" has changed or evolved beyond mainstream AI and is being re-branded, though the ideas of AI are not new.

Besides the attempt to define AI based on its original meaning, though under new names now, the speculative nature of terms such as "superintelligence" by Kurzweil or "singularity" by Bostrom aim to achieve higher goals beyond human intelligence in machines.[90] Technical experts are attempting to develop AGI, or "strong" intelligence, to

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[87] Bourbakis, *Artificial Intelligence and Automation*.

[88] "What Is Narrow AI?," Narrow AI, accessed April 27, 2020, https://deepai.org/machine-learning-glossary-and-terms/narrow-ai.

[89] Ben Goertzel and Cassio Pennachin, *Artificial General Intelligence* (New York: Springer, 2007); Pei Wang and Ben Goertzel, "Introduction: Aspects of Artificial General Intelligence," in *Proceedings of the 2007 Conference on Advances in Artificial General Intelligence: Concepts, Architectures and Algorithms*, ed. Ben Goertzel and Pei Wang (Amsterdam: IOS Press, 2007), 1–16.

[90] Ray Kurzweil, *The Singularity Is Near: When Humans Transcend Biology* (New York: Penguin Books, 2006); Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford, UK: Oxford University Press, 2014).

a level of imitating the human brain. ASI is the goal of AI in which a robot demonstrates all human-like cognitive and physical being, like the human-like robot named Sonny in the 2004 film "I, Robot" starring Will Smith.[91] This study does not consider these concepts as realistic and will not analyze them in this thesis. Authors such as Wang, Liu, and Doughtery have argued that even though computer programs or algorithms can replicate human tasks, AGI is not the same as human flesh or human experiences and will not lead to singularity.[92]

The 2018 DOD AI Strategy explicitly states that AI one technological advancement that refers to machines performing a task that a human being would perform.[93] China's New Generation AI Development Plan—along with Made in China 2025 released in May 2015—does not have a clear definition but, rather, focuses on the development stage within the science, technology, research, and development stage with the core AI policy on intellectual property and intellectual rights.[94] Both nations with different values will likely have different definitions and perceptions of automation.

3. Conceptualizing Automation

The first step is to categorize automation and then separate the definitions into three levels of complex applications: simple, complex, or very complex, according to the consulting firm PricewaterhouseCoopers (PwC).[95] Simple automation can be as simple as commercial use to manage Navy resources or personnel. Figure 2 conceptualizes how to adopt automation and AI because of the varying levels of complexity ranging from augmentation, assisted, and autonomous intelligence.

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[91] Rosario Girasa, *Artificial Intelligence as a Disruptive Technology: Economic Transformation and Government Regulation* (New York: Springer International Publishing, 2020), 10–11.

[92] Pei Wang, Kai Liu, and Quinn Dougherty, "Conceptions of Artificial Intelligence and Singularity," *Information* 9, no. 4 (2018): 1–2, https://doi.org/10.3390/info9040079.

[93] The United States government has a clear definition in its AI strategy whereas China uses a development plan.

[94] China Institute for Science and Technology Policy, *China AI Development Report 2018*, 76.

[95] Scholoer Consulting Group, "What Is Artificial Intelligence?," Understanding Artificial Intelligence, accessed January 27, 2020, http://www.schloerconsulting.com/understanding-artificial-intelligence.

Figure 2. Human Decisions Supplemented by AI Along with AI Continuum[96]

This graph was developed by PwC as an analytical tool to display how the AI continuum is different from each category of automation. The three main differences are assisted intelligence, augmented intelligence, and autonomous intelligence. In naval affairs, the U.S. maritime battlefield decision aid called the COP (see Figure 3), is an assisted intelligence tool that automates tracking of naval platforms radiating their unique identifiers at sea or on land.[97]

[96] Source: Mike Quindazzi (@MikeQuindazzi), "Human decisions supplemented by #ArtificialIntelligence along the #AI continuum; 1-#augmented, 2-#assisted, 3-#autonomous. #pwc," Twitter, March 22, 2017, 9:15pm., https://twitter.com/mikequindazzi/status/844764424917286912

[97] Gary Koch, "NORAD-USNORTHCOM C2 Systems Overview for AFCEA JC2C: Evolving the GCCS FoS" (AFCEA Course, Fairfax, VA, March 25, 2010), slide 22, https://www.slideshare.net/gdkochjr/afcea-jc2c-gccs-presentation.

Figure 3. Common Operational Picture for Situational Awareness for Operators[98]

4. Levels of Automation

The human operators behind automated computers and offer machines can better adopt automation through understanding the various levels of automation. The Sheridan and Verplank's Scale of Human-Machine Interaction on automation, shown in Table 4, describes levels 1 through 10 on systematic work that has been done to evaluate the key levels of automation. The highly automated systems such as the U.S. Aegis combat system and *Dragon Eye* improve automation for decision making and allows the human operator to make decisions within each level and make the final decision.

Table 4 conceptualizes the degree of automation one requests from entirely manual to entirely automatic (along the x-axis) and, the level of task entropy from prespecified task to unpredictable future requirements along (along the y-axis).

98 Source: Koch, "NORAD-USNORTHCOM C2 Systems.".

Table 4. Levels of Automation[99]

Automation Levels	Automation Description
1	The computer offers no assistance: human must take all decisions and actions
2	The computer offers a complete set of decisions/actions alternatives, or
3	Narrows the selection down to a few, or
4	Suggests one alternative, and
5	Executes that suggestion if the human approves, or
6	Allows the human a restricted time to veto before automation execution, or
7	Executes automatically, then necessarily informs humans, and
8	Informs the human only if asked, or
9	Informs the human only if it, the computer, decides to.
10	The computer decides everything and acts autonomously, ignoring the human.

The concept of automation levels ranges from manual to full autonomy.[100]

Based on research by Sheridan and Verplank, automation can override human operators to execute a task and may not be the fittest in a changing environment.[101] While automation levels are designed for consistent quality control and performance checks, the levels of automation also assist with re-evaluation and adjustments for improvements in a system or management systems that can range from manual to fully automated. Thus, if he or she understands the various levels of automation, then the human operator can adapt to accomplish the mission (depending on the level of failure) when failure within automation may occur.

Sheridan and Verplank's entropy scale from Figure 4 can helps decision-makers gain awareness and recognize the intricate level between entropy and automation and applied appropriate can better assist commanders in the business of naval ISR.

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99 Thomas Sheridan and William Verplank, *Human and Computer Control of Undersea Teleoperators* (Cambridge, MA: Massachusetts Institute of Technology, 1978).

100 Heather M. Roff and David Danks, "'Trust but Verify': The Difficulty of Trusting Autonomous Weapons Systems," *Journal of Military Ethics* 17, no. 1 (2018): 20, https://doi.org/10.1080/15027570.2018.1481907.

101 Sheridan and Verplank, *Human and Computer Control of Undersea Teleoperators*.

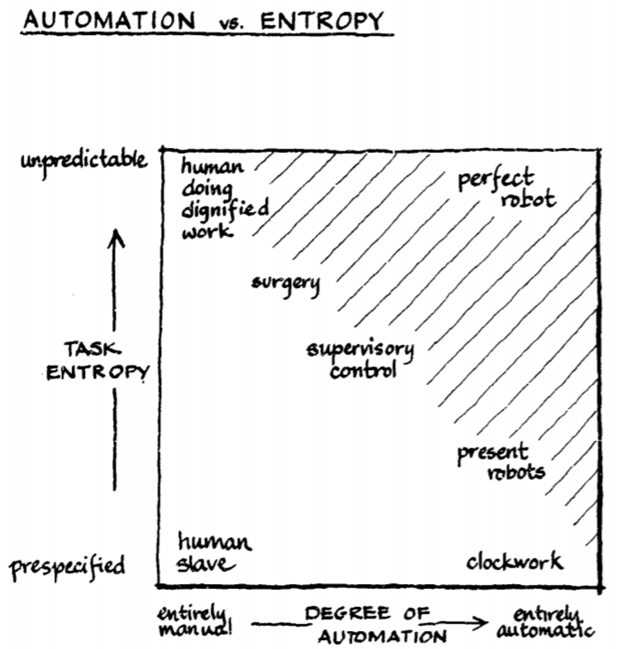

Figure 4. Automation and Task Entropy Continuum to Help Solve Problems with AI[102]

This study shows that there is a variety of definitions and interpretations of automation and AI across numerous studies. Most scholars, researchers, and commanders can readily agree that techniques can be automated, through a set of rules, for faster results by computers; normally a human being would take longer to accomplish several analytical or mathematical problems using a computer.

D. NAVAL ISR

Part one of this research methodology will be a qualitative research design in five parts. First, I will discuss how naval leadership is adopting aircraft carriers, ships, and aircraft and to compare Western versus Eastern naval leadership. Second, I will breakdown the main intelligence domains within which automation and AI are used: IMINT, SIGINT, OSINT, MASINT, HUMINT. Third, I will cover the current development of hardware and software on U.S. Aegis, Ship's Self Defense (SSDS) and Type-346 sensors, and relevant radars used for ISR.

[102] Source: Sheridan and Verplank, 4–7.

1. U.S. Naval Leaders Pursue Automation and AI

In the naval business of ISR, Western leadership has always had a keen eye and thirst to know and understand the adversary. Abraham Lincoln once said, "I do not like that man. I must get to know him better. I do not like that person, I must get to know them better."[103] Naval ISR is a profound art of war in the pursuit to know and understand the adversary and noticing a pattern of life at sea and abnormal or amalgam within a naval pattern of life; therefore, it contributes to understanding the Navy that which is better than one's own Navy.

Policy plays a key role in improving naval ISR. In Carl von Clausewitz's *On War*, he states that "war is nothing but the continuation of policy with other means."[104] United States Naval policy on ISR is promulgated in the 2017 Joint Publication 2-01.[105] Naval ISR is an instrument to be used in times of war and peacetime where the sea is a highway, as Alfred Thayer Mahan put, "over which men may pass in all directions…familiar and unfamiliar dangers of the sea, both travel and traffic by water" has been easier and cheaper.[106] Knowing the adversary or competitor requires the collection of intelligence and knowledge of what lies on the highways or sea lanes. The policy set by acting CNO Mike Gilday and his predecessor Adm. John Richardson is to maintain maritime superiority; the mission is to protect America from attack, preserve strategic influence…and to modernize the U.S. Navy.[107]

Over the next decade, both the *Ford*-class nuclear-powered aircraft carrier and the Chinese Type 001 "Liaoning," Type 002 "Shandong," as shown in Figure 5, and future aircraft carriers will remain symbols of maritime superiority and project power, but may

[103] Daniel Coenn, *Abraham Lincoln: His Words*, ed. Maureen Harrison and Steve Gilbert (New York: Barnes & Noble, 1994).

[104] Carl von Clausewitz, *On War*, ed. Michael Howard and Peter Paret, Reprint (Princeton, NJ: Princeton University Press, 1989), 69.

[105] See Joint Chiefs of Staff, *Joint Intelligence Support to Military Operations*, Appendix B-1.

[106] Alfred Thayer Mahan, *The Influence of Sea Power Upon History, 1660–1783* (New York: Dover Publications, 1987), 25.

[107] Richardson, *A Design for Maritime Superiority*.

not be the main line of effort at sea.[108] The aircraft carrier represents "National Command Authority and warfighting Commanders-in-Chief with a flexible force to respond to a wide variety of international challenges…four and one-half acres of sovereign-and mobile-American territory that can project U.S. power whatever it might be required."[109] However, part of the ISR situational awareness calculus will be greatly improved with both unmanned aerial vehicles (UAV), unmanned undersea vehicles (UUV), and manned naval platforms. Unmanned and manned ISR platforms in addition to the Navy's nuclear aircraft carrier and amphibious aircraft carriers—used to deploy troops on the ground—represent maritime superiority.

Figure 5. Shandong (Type 001A) Aircraft Carrier[110]

Where there is the naval theorist Mahan in the West, there is Sun Tzu in the east. Unlike the Western concept of not politicizing the military, the East has the opposite concept, which is to politicize the military because the party controls the military.[111] The

[108] "The Aircraft Carrier Plan: A Dual-Track Strategy," Aircraft Carriers, accessed February 21, 2020, https://fas.org/man/dod-101/navy/docs/vision/carriers.htm.

[109] Federation of American Scientists.

[110] Source: Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, CRS Report No. RL33153 (Washington, DC: Congressional Research Service, 2020), 10, https://crsreports.congress.gov/product/pdf/RL/RL33153/233.

[111] Richard McGregor, "5 Myths about the Chinese Communist Party," *Foreign Policy*, January 3, 2011, https://foreignpolicy.com/2011/01/03/5-myths-about-the-chinese-communist-party/.

PLAN is the party's naval force and continues to build aircraft carriers. PLAN platforms today consist of 86 Missile Patrol craft, 28 Corvettes, 26 Medium Landing Ships, 28 destroyers, and 41 frigates.[112] The PLAN have more small missile boats, torpedo boats, and long-range weapons than aircraft carriers, which shows that China does not need aircraft carriers to operate effectively.

2. PRC Naval Leaders Pursue Automation and AI

Naval ISR can be viewed as an element of spy-craft on par with the livelihood of water and in execution, achieve great results. In Sun Tzu's book "Art of War," his chapter on the "Use of Spies" states, "Hence it is only the enlightened ruler and the wise general who will use the highest intelligence of the army for purposes of spying…Spies are a most important element in war, because on them depends an army's ability to move."[113] Chinese naval leadership likely uses ISR as spies in support of moving the army when necessary.

The PLAN is currently modernizing its naval battle group structure. In 2012 at the 18th Party Congress, then-President Hu Jintao called for China to become a "maritime power." In April 2018, President Xi-Jinping echoed this vision and stated that "the task of building a powerful navy has never been as urgent as it is today."[114] China's 2019 Defense White Paper states:

> The PLA Navy (PLAN) has extended training to the far seas and deployed the aircraft carrier task group for its first far seas combat exercise in the West Pacific. It has organized naval parades in the South China Sea and the waters and airspace near Qingdao, and conducted a series of live force-on-

[112] Defense Intelligence Agency, *China's Military Power* (Washington, DC: Defense Intelligence Agency, 2019), 68, https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/China_Military_Power_FINAL_5MB_20190103.pdf.

[113] Sun Tzu, *Sun Tzu on the Art of War: XIII. The Use of Spies*, trans. Lionel Giles, 1994, https://fas.org/man/artofwar.htm#13..

[114] China Power Team, "How Is China Modernizing Its Navy?," China Power, December 17, 2018, https://chinapower.csis.org/china-naval-modernization/.

force exercises codenamed Mobility and systematic all-elements exercises.[115]

The PLAN's modernization and extended sea training, live-fire exercises, and red versus blue exercises with its aircraft carrier task group indicate great improvement of its automation capabilities in the littorals (see Figure 6). This trend, set by President Xi-Jinping, indicates the PLAN will likely develop and test automation and AI analytical tools to increase productivity in its training environment, in exercises, and operations to the far seas. Figure 6 depicts an approximation of PLAN's order of battle in each theater of operations that can support naval ISR.

Figure 6. China's Military Power - DIA's 2019 PLAN Fleet Composition in Support of Naval ISR[116]

The major plans and timelines between the two navies illuminate their organizational differences. With China, its desires for rapid modernization is clear but focused more on developing automation. In Mao Tse-tung 's 1936 "Problems of Strategy

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115 Anthony H. Cordesman, *China's New 2019 Defense White Paper: An Open Strategic Challenge to the United States, But One Which Does Not Have to Lead to Conflict* (Washington, DC: Center for Strategic & International Studies, 2019), https://csis-prod.s3.amazonaws.com/s3fs-public/publication/190724_China_2019_Defense.pdf.

116 Source: Defense Intelligence Agency, *China's Military Power*, 68.

in China's Revolutionary War," the first chapter revolves around the laws of war being developmental at all levels in conjunction with China's Five-Year Plan, which demonstrates a similar strategy of development for AI today.[117] This plan specifies a major scientific and technological infrastructure construction plan through 2020 and "Defense and Dual-Use Plans and Strategies."[118] Today, both U.S. CNO and PLAN Commanders strongly emphasize automating naval ISR for situational awareness.

3. Technical Naval ISR

Intelligence, surveillance, and reconnaissance are three separate but vital functions that represent the defense trinity. The U.S. Navy-Marine team and the People's Liberation Army Navy team orchestrate ISR for situational awareness in which automation plays a vital role in national security and national defense. On January 14, 1991, the Joint Surveillance and Target Attack Radar System, a new system called JSTARS, was the first operational employment and deployment during Operation Desert Shield (ODS) in the Persian Gulf.[119] There was a strong belief and justification for ISR capabilities because locating and destroying Scud missiles in Iraq was a vexing problem not solved in the ODS. ISR via JSTARs was meant to fill this gap that could provide wide-area, long-range surveillance through a moving target indicator (MTI) and a battle management technological aid.

JP 1-02, Department of Defense (DOD) Dictionary of Military and Associated Terms defines intelligence, surveillance, and reconnaissance (ISR) as: "An activity that synchronizes and integrates the planning and operations of sensors, assets, processing, exploitation, and dissemination systems in direct support of current and future

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[117] Mao Tse-tung, *Problems of Strategy in China's Revolutionary War*, Selected Works of Mao Tse-Tung (Peking: Foreign Language Press, 1936), https://www.marxists.org/reference/archive/mao/selected-works/volume-1/mswv1_12.htm.

[118] Katherine Koleski, *The 13th Five-Year Plan* (Washington, DC: U.S.-China Economic and Security Review Commission, 2017), 43, https://www.uscc.gov/sites/default/files/Research/The%2013th%20Five-Year%20Plan_Final_2.14.17_Updated%20%28002%29.pdf.

[119] Nordin Yusof, *Space Warfare: High-Tech War of the Future Generation* (Skudai, Malaysia: Penerbit Universiti Teknologi Malaysia, 1999), 222.

operations."[120] This joint intelligence operation consists of global naval ISR platforms that, when tasked, starts the first stage of a battle to locate and identify adversary forces or a specific target. As shown in Figure 7, the ISR process synchronizes with both intelligence collection management and current operations.

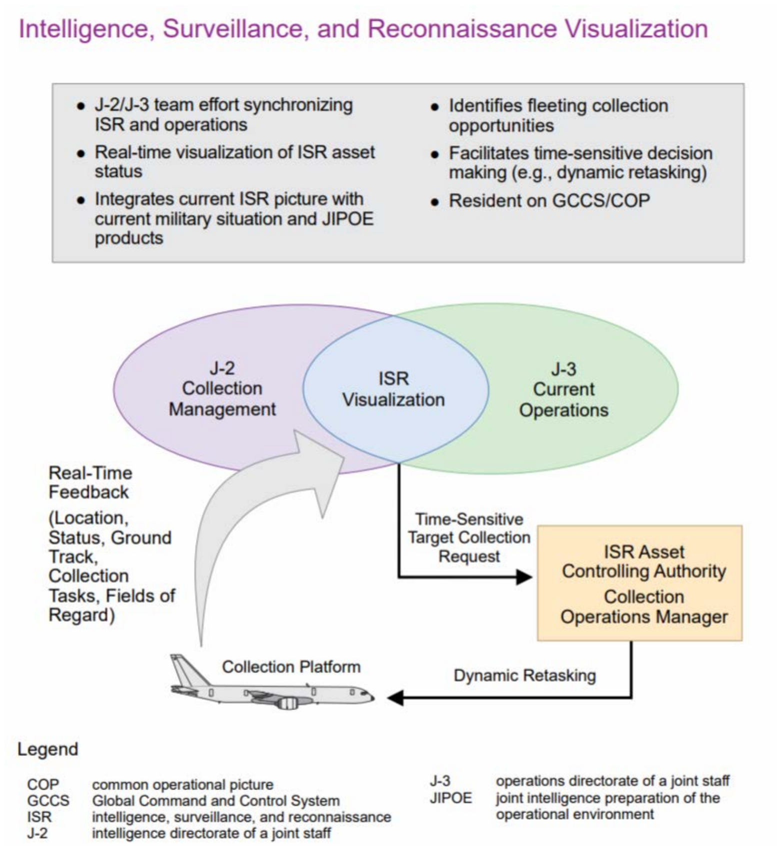

Figure 7. Venn Diagram on ISR Visualization to Show Teamwork Between Intelligence Collection (J2) and Operations (J3)[121]

Given the mission and task, the first stage of a battle is to locate, identify, and collect data from remote sensors such as Aegis automation system, visualize the data via computer software, such as GCCS; and, deliver relevant and accurate exploited and analyzed intelligence to the customer. ISR is quite the iterative process, slow or fast.

[120] Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms*, 116.

[121] Source: Joint Chiefs of Staff, *Joint Intelligence Support to Military Operations*, III–33.

4. U.S. Aegis

There are two significant advanced automated weapons systems in the U.S. Navy and the PLAN, the west and the east, which accelerate and bring automation to life—Aegis and the Dragon Eye combat systems. First, Aegis has played a pivotal role over the last sixty years on adaptive ship's self-against aircraft, anti-ship missiles, surface threats, and subsurface threats— "an integrated collection of sensors, computers, software, displays, weapon launchers, and weapons named for the mythological shield that defended Zeus."[122] Aegis was initially developed in November 1963, which was called the Advanced Surface Missile System (ASM) Project. Later in 1969, ASM was renamed to Aegis with an awarded contract to Radio Corporation of America (RCA), which is the legacy industrial corporation of Lockheed Martin. The only streamlined consistency was the comfortable jumper, bell-bottom style uniforms—called coveralls—that the Sailors wore while using this combat system.

Historically, it has taken decades to field and successfully use automation for ship self-defense at sea. About 10 years after initial development, the Army-Navy SPY-1 radar associated with Aegis successfully tracked its first target at the land-based test site and then operated at sea onboard USS NORTON SOUND (AVM-1). It took nearly 20 to 30 years of research, development, and testing to successfully use this automation tool.[123] For example, in 1982 the U.S. Navy conducted two successful intercepts with SM-1 missiles via TICONDEROGA-class cruisers (also onboard Arleigh Burke-class destroyers) and then in 1991, USS SAN JACINTO fired its first Tomahawk land-attack missile (TLAM) to strike Baghdad in Operation Desert Storm in the Red Sea.[124] The COP, fueled by Aegis and SPY-1 radar, is significantly important for indications and warning for ship's self-

[122] Ronald O'Rourke, *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress*, CRS Report No. RL33745 (Washington, DC: Congressional Research Service, 2018), https://crsreports.congress.gov/product/pdf/RL/RL33745/189.

[123] James C. Bussert and Bruce A. Elleman, *People's Liberation Army Navy: Combat System Technology, 1949–2010* (Annapolis, MD: Naval Institute Press, 2011).

[124] Joseph T. Threston, "The AEGIS Weapon System," *Naval Engineers Journal* 121, no. 3 (October 2009): 85–108, https://doi.org/10.1111/j.1559-3584.2009.00205.x.

defense and executing a presidential order to launch and re-launch missiles on a prioritized target.

Launching a strike on Baghdad set a precedent for launching a missile from the sea and human operators watching this launch on a screen similarly displayed as a video game console. The easiest way to track an aircraft or ship is by the navigational radar, which falls Naval law, according to the United Nations Convention on the Law of the Sea and Naval Warfare Planning 1–14M (Law of Naval Operations).[125] This brought forth meaning and necessity for the U.S. DOD and the U.S. Navy, to have a justification to adopt naval ISR.

The U.S. Navy is adopting automation technologies for battlespace awareness. "The battlefield technologies of electronic warfare, intelligence, and battlefield automation, as well as precision-guided munitions, thus generated responses in each of the services: Aegis for the Navy, AWACS for the Air Force, and CEWI for the Army."[126] For the navy, automating high energy laser weapons onboard Aegis Baseline 10, is being developed and testing onboard the future *USS Jack H. Lucas* (DDG-125) with SPY-6 radar by 2023.[127] Lockheed Martin received a USD 150 million contract to integrate High Energy Laser Weapon Systems development, manufacture, and delivery for ISR.[128] Ship automation combined with target acquisition benefits naval ISR by automating tasks for situational awareness and self-defense.

Today's Aegis program management is faster than the previous procurement and fielding timelines. For example, the Office of the Chief of Naval Operations N9 department (Warfare Systems) implemented a $294 million in contracts for the "2-4-6" program for

[125] Department of the Navy, *The Commander's Handbook on the Law of Naval Operations* (Washington, DC: Office of the Chief of Naval Operations, 2017), https://www.hsdl.org/?view&did=806860; United Nations Convention on the Law of the Sea, opened for signature December 10, 1982, 1833 U.N.T.S. 3, 397; 21 I.L.M. 1261 (1982) (entered into force Nov. 16, 1995) [hereinafter UNCLOS].

[126] Kenneth Allard, *Command, and Control, and the Common Defense* (Fort McNair, Washington, DC: National Defense University, Institute for National Strategic Studies, 1996), 148, 163.

[127] Ben Werner, "Aegis Combat System Baseline 10 Set to IOC in 2023," USNI News, January 15, 2019, https://news.usni.org/2019/01/15/40397.

[128] "Lockheed Martin Receives $150 Million Contract to Deliver Integrated High Energy Laser Weapon Systems to U.S. Navy," Lockheed Martin Newsroom, March 1, 2018, https://news.lockheedmartin.com/2018-03-01-Lockheed-Martin-Receives-150-Million-Contract-to-Deliver-Integrated-High-Energy-Laser-Weapon-Systems-to-U-S-Navy.

modernizing existing Aegis ships, specifically cruisers that primarily serve as the air defense command.[129] "No more than two of the cruisers are to enter the modernization program each year, none of the cruisers is to remain in reduced status for modernization for more than four years, and no more than six of the cruisers are to be in the program at any given time."[130]

5. PLAN Type-348 Dragon Eye

Since the 1950s, the CCP inherited a large number of American and Japanese navy ships, and rest were provided by the Soviet Union after its collapse in 1991.[131] This is the reason why PLAN *Liaoning* aircraft carriers look quite like the Russian *Kuznetsov*-class aircraft carrier. In 1998, the Chinese Research Institute in Nanjing developed a prototype Type 346 and upgrades to the *Dragon Eye* phased array radar utilizes the S-band to further improve surveillance radar for satellite communications, air traffic control, weather radar, and surface ship radar.

Over the past twenty years, the PLAN has developed plans to make progress by combining foreign and domestic military equipment. According to China's 13th PLA "Five Year Plan," its Navy is moving toward an "Intelligentized Age."[132] To reach this level of intelligence and apply it to the Navy, the PLAN built two domestically designed naval destroyers (DDGs) with Aegis-like phased-array panels. The *Mineral Me* "*Band Stand*" one of PLAN's data track and weapons control system with a passive range of 242 nautical miles (nm) and active range of 97 nm (some say up to 134 nm).[133] As for PLAN's data link system, the Chinese integrated datalink system is called the Joint Service Integrated Datalink System (JSIDLS), which plays the key, if not the most important role, in

129 David B. Larter, "With $294 Million in Contracts, the U.S. Navy Keeps Its Promise to Upgrade Cruisers," *Defense News*, August 24, 2018.

130 O'Rourke, *Navy Aegis Ballistic Missile Defense (BMD) Program*, 1.

131 Bussert and Elleman, *People's Liberation Army Navy: Combat System Technology, 1949–2010*.

132 Graham Winstanley, ed., *Artificial Intelligence in Engineering* (Tiptree, Essex, UK: Courier International Ltd, 1991).

133 Sarah Kirchberger, *Assessing China's Naval Power: Technological Innovation, Economic Constraints, and Strategic Implications* (Berlin: Springer-Verlag, 2015), 192.

connecting networks and communication for PLAN naval ISR platforms.[134] *Mineral Me* and JSIDLS are very comparable to *Aegis* and Link-16. AI venture capitalists Kai-fu Lee would reinforce this behavior as "China copycats."[135] The challenge for the PLAN is not their automation and *Dragon Eye* sensor capabilities but, rather, their ability to adapt and operationalize their ISR equipment and platforms in a joint environment.

The Chief of Naval Operation's (CNO) Maritime Design 2.0 aims squarely at competing with Near Peer competitors such as China and Russia and the U.S. Navy must be agile to keep pace with technology. Automation is important because it helps us learn more about ourselves and how the U.S. Navy operates compared to the PLA Navy. First, it provides situational awareness for trend analysis or early I&W. Second, automation is more than your average fascination because it can automatically perform a task faster than a human being can. Third, algorithms written by humans help fill the human gap of understanding and recognize trends more quickly than a human can. While predicting the future in detail is near impossible, automation can assist human beings in recognizing patterns of behaviors or trends to increase the chances of forecasting what the opponent's next move might be. Thus, continuously making the effort to continuously learn about automation combined with AI software can significantly contribute to the adoption process.

[134] Kirchberger, 201.

[135] Lee, *AI Superpowers*.

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III. METHODOLOGY

Many theoretical and systems engineering design methods exist to illustrate a complex adaptive process of implementing automation and AI technologies. Less is known, however, about the dynamic process of adoption, including related factors about decisions as to how to increase or decrease adoption of automation and AI pertaining to naval ISR. According to researchers from George Washington University and New York University, the need for adoption becomes apparent because of a knowledge gap, a search for solutions, an initial decision to a specific technological solution, and an implementation of the solution.[136] The overall goal is to identify emerging technologies with Artificial Intelligence across the S-Curve adoption framework that are possibly modifiable, and thus, demonstrate ways that improve naval ISR for sea power.

A. S-CURVE METHODOLOGY

To explore the adoption of automation in naval ISR between the two AI superpower navies, this thesis will use Everett Rogers' 1962 S-curve model of the diffusion process. This proposed step-by-step process would encourage the Department of the Navy to analyze both automated systems and AI for naval ISR every quarter within a fiscal year. Quarterly reports can help improve the adoption process with updated or upgraded tactics, techniques, and strategies, to harness new AI technologies. This "how to" format will be illustrated through a systematic and flexible design model that can be applied and re-applied quarterly because of the emerging technologies that outpace current naval programs. Quarterly reports are critical feedback and auditing tool necessary to conduct performance measures and stay competitive.

[136] See various adoption models for different complex adoption problems by the following sources: Fariborz Damanpour and Marguerite Schneider, "Phases of the Adoption of Innovation in Organizations: Effects of Environment, Organization and Top Managers," *British Journal of Management* 17, no. 3 (September 2006): 215–36, https://doi.org/10.1111/j.1467-8551.2006.00498.x; Michael J. Gallivan, "Organizational Adoption and Assimilation of Complex Technological Innovations: Development and Application of a New Framework," *The DATABASE for Advances in Information Systems* 32, no. 3 (Summer 2001): 51–85, https://doi.org/10.1145/506724.506729; and Peter Mendel et al., "Interventions in Organizational and Community Context: A Framework for Building Evidence on Dissemination and Implementation in Health Services Research," *Administration and Policy in Mental Health* 35, no. 1–2 (March 2008): 21–37, https://doi.org/10.1007/s10488-007-0144-9.

B. 7 STEPS TO ADOPTING AUTOMATION AND AI FOR NAVAL ISR

There are three major categories when applying the S-curve of technological adoption: (1) Construct: an idea or theory containing subjective and conceptual elements, (2) Pre-adoption phase: awareness of innovation (early innovators and early adopters), and (3) Adoption phase: adopter's commitment to the decision.[137]

1. Start with a "Campfire Talk"

Beginning with a "campfire talk" can build a holistic way of understanding a competitor's vision and where successful emerging technologies are applied along the S-Curve. American strategist and the University of Virginia Professor Jeanne Liedtka encourages her readers to have an open mind of what the world might be, specifically a "'purposeful space'—virtual rather than physical—in which particular activities, capabilities, and relationships are encouraged" to produce particular behaviors. This step is essential in building a process of design.[138] The most important aspect relevant to initial campfire discussions can fundamentally be getting to know each other, and definition and perception of automation and AI priorities, and write the tasks that require solutions down.

2. Categorize and Analyze the Competing Naval Leaders of Other Great Powers

In this step, begin with the vision and strategic narratives for great sea power, and dive into the organizational and cultural factors. The rationale for choosing this method of analysis is that those in power make or create change in a complex and adaptive system. Thus, understanding the leaders will likely contribute to building awareness. By building awareness, the cognitive mind can recognize the subtle similarities and differences between competing naval powers.

[137] Jennifer P. Wisdom et al., "Innovation Adoption: A Review of Theories and Constructs," *Administration and Policy in Mental Health* 41, no. 4 (2014): 480–502, https://doi.org/10.1007/s10488-013-0486-4.

[138] Jeanne Liedtka, "In Defense of Strategy as Design," *California Management Review* 42, no. 3 (Spring 2000): 9, https://doi.org/10.2307/41166040.

3. Understand Each Intelligence Organization's Technical Capabilities

An easy approach is to use the SWOT technique, which is understanding Strengths, Weaknesses, Opportunities, Threats (SWOT). Specifically, this requires selecting a current situational awareness computer system, its associated radar capabilities, such as Aegis and Type-346, and the physical naval platform. If there are more weaknesses and threats, then the program or plan can be re-organized or canceled in order to build strength and create more opportunities to compete in leading in AI for future sea power.

4. Select and Categorize Top-Performing AI through Social Network Analysis (SNA)

This step gears toward identifying and leveraging key talent quickly. Key talent includes available or already-built software applications, hardware, and relevant researchers and developers on the market. A place to start is with open-source databases with subject matter experts, intelligence professionals, and operator professionals who publish his or her work online. For SNA, programming platforms such as RStudio, ORA, or Gephi can assist human operators in identifying well-networked and hidden talents worldwide (see the appendix).

5. Combine Relevant and Operator-Oriented and Intelligence-Oriented Services

This step helps generate or catalyze the flow of adoption from pre-adoption among the early innovators to adoption phase by promoting awareness to achieve automation and AI goals within each intelligence category.

6. Review and Re-orient

Review and reorient for feedback, with oneself or with a diverse team, and return to the specific step to be addressed. Receiving senior level feedback within 10 weeks prior to quarterly reports is critical to competitive because the awareness and knowledge of specific automation or AI tool that shows a lack of progress, productivity, or compatibility degrades the design process in long-term strategy if the problem or set of problems are not identified throughout the process.

7. Publish and Make the Plan Accessible

Lastly, finalize the plan and make it accessible upon publishing the quarterly measures of performance and effort from the commands and encourage flexible and changeable plans.

These are the elements necessary for identifying and detecting where people or emerging technologies may or may not fall within the five categories of Rogers' S-Curve model. Similar to American historian of technology Elting Morison's research and reflection process, much of the adoption of automation centers change or resistance to change, and understanding why changes occur.[139] With the steps in mind, I will use Morison's research and reflection process to analyze the combined information and intelligence.

C. UNDERSTANDING THE S-CURVE THEORY OF TECHNOLOGICAL ADOPTION

The history of the S-curve idea began in the 19th century with the motivation of knowing more about the growth of humans as a logistic function. In 1839, a Belgian mathematician Pierre-Francois Verhulst, who related this theory to population growth, introduced the logistic curve, or "S-curve," theory. Verhulst initially conceived his idea from the Englishman and political economist Thomas Malthus' "An Essay on the Principle of Population" in 1789. In this time, food supply was declining and therefore, feeding the greater population became difficult.

However, since the 1950s, the growth of automation technologies has not been surprise. According to Modus the S-Curve, "the rate of growth is proportional to both the amount of growth already accomplished and the amount of growth remaining to be accomplished."[140] Understanding categories of people and their key or hidden talents can be applied to the S-curve. According to American communication theorist and sociologist Everett Rogers developed the diffusion of innovation theory in 1962, there are five

139 Morrison, *Men, Machines, and Modern Times*, 7.

140 Lindgren, "Global Remittances and Space-Based Cryptocurrencies," 79.

categories of the adoption (see Figure 8).[141] The successful adoption of an innovative technology occurs in a distributed bell-shaped curve, S-shaped. The S-Curve is derived from the diffusion curve with respect to time and normality. The point of inflection or saturation to avoid is where the two lines intersect between early majority and late majority.

Figure 8 depicts the rate of technology adoption in the form of a horizontal and stretched "S" with adoption on the Y-axis and time on the X-axis.

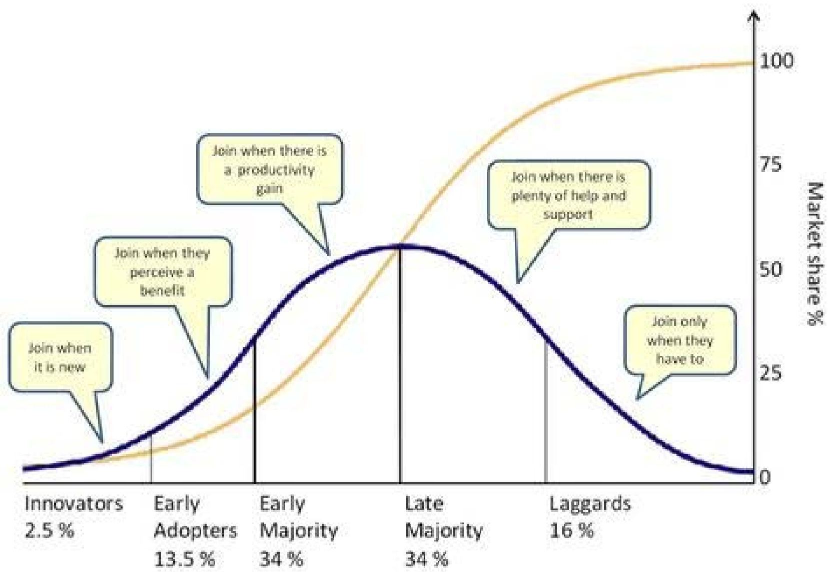

Figure 8. S-curve Model of Diffusion Process[142]

The five groups can be shown through the S-curve to understand who, at what sequence, and at what speed adopts emerging technologies. The first group of innovators are the first people to adopt an emerging technology without consumers or users testing it and account for an average of 2.5 percent of innovators. The second cohort is made up of early adopters and accounts for 13.5 percent. The early adopters are the second wave of purchasers. The third group is the early majority and account for 34 percent when the product has become mainstream products by this time. The fourth group are the late

[141] Schwieterman and Fischer, "The S-Curve of Technological Adoption."

[142] Source: Schwieterman and Fischer, 3.

majority and represent 34 percent and cautious adopters. The fifth group are the laggards and consist of 16 percent; similar to people who start to use the internet or smart phones today. These percentages can form a bell curve however, the sum of waves these groups adopting an emerging technology over time becomes in the shape of an S-curve in terms of time.

The first group is the incubation period in which a technology has potential for growth or improvement but has significant problems to overcome before becoming mainstream. The next stage is where the technology has shown rapid improvement and cost efficiency. After this stage, the technology matures and shows limitations. Examples in modern society include Airbnb or Uber services and associated user-friendly AI applications. Typically, this growth can lead to the stereotypical name of disruptive technologies.

Rogers' theory can serve as a pivotal methodology of adoption. It opens a way to begin designing and strategizing how to adopt innovative technologies. For example, to stimulate strategy and game theory, there are strategy games such as AlphaGo deep-learning system and IBM's DeepMind subsidiary of Google to play the strategy game of Go or Weiqi (pronounced "way-chee"). In 2016, the computer system AlphaGo defeated South Korean Grandmaster Lee Sedol, which demonstrated an innovative technology that can beat a human being at a strategy game.[143] This directly relates to a computer system that beat a human being with the strategic advantage of AI having both different strategic options and speed.

D. MILLENNIALS, GEN-Z, AND ZENIALS

In the context of future sea power, the naval leaders in the next 10 to 20 years will be millennials and generation Z, also called Gen-Z. These are the groups of people who grew up with automation and AI technologies. Michael Dimock, a Pew Research Center researcher on U.S. politics, policy, demographics, and social trends, defines millennials as "anyone born between 1981 and 1996 (ages 23 to 38 in 2019)" and those born after 1997

[143] Silver et al., "A General Reinforcement Learning Algorithm."

are Gen-Z. For example, the U.S. intelligence specialists operating and maintaining the automation tools, ages 18 to 30, grew up with technologies; the tactical operators are also culturally known as millennials or Gen-Z. Both generations can be the best advocates to discuss awareness, recognize, and apply technological AI tools for ISR. It is important to note that early innovators, who can be in any age group, are typically found more frequently in the younger population because they used emerging technologies as a child and can identify and reveal inoperable or non-compatible issues quickly.

Commercial and private sectors recognize automation and AI as engineering problems. Former CEO of Google and board member of the DOD Advisory board Erich Schmidt believe the problems are straightforward engineering problems that need to be "done right." He believes the biggest issue remains with multiple systems not being compatible with one another. One of the solutions he proposes is to build reliable systems in which we understand failure modes and error rates.[144] For example in the Navy, receiving, analyzing, and disseminating data via Aegis and multiple other computer systems inevitably creates a recognized frustration among the younger operators. Given the Navy's antiquated system, this reveals a weakness in the adopting automation because envision computer systems and AI applications, like a high-resolution video game or Apple product; the adoption process here is a little behind "the curve."

E. ALTERNATIVE OUTLOOK TO ROGERS' S-CURVE

Lessons learned from the past can be applied to the S-Curve model to show how and how not to adopt automation for naval ISR. As an alternative method, I will also use quantitative measures to show relational, spatial, and temporal network analysis of relevant AI researchers who are researching AI. Data will be from open-source and public databases such as Stanford University's arXiv database and Clarivate Analytics' Web of Science database.[145] This will contribute to purely the awareness automation and AI research today to stay ahead of the curve of adoption.

[144] Scharre, Cho, and Schmidt, "Eric Schmidt Keynote Address."

[145] "Web of Science," Web of Science Group, 2020, https://clarivate.com/webofsciencegroup/solutions/web-of-science/.

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IV. AI SUPERPOWER NAVIES ADOPTING AUTOMATION TODAY

> The ultimate impact will depend not just on how the principles actually shape DOD investments in AI, but in how the broader AI community perceives DOD actions.[146]
>
> —Professor Michael C. Horowitz (University of Pennsylvania)

Great powers with a grand narrative about global affairs often have a gravitational pull. For example, after World War II, the U.S. government put forth all efforts to contain the Soviet Union. In the aftermath of 9/11, the Global War on Terror (GWOT) became a grand narrative. More recently, the U.S. and PRC have become driven to some extent by efforts to outpace or leapfrog over the other in the AI realm. We find ourselves—as shown from both governments' national strategy documents, media coverage, think tanks, universities, public and private companies—in an era of "Great Power Competition" and the narrative today between the great powers of the United States and China increasingly relates to the arms race associated with the military application of Artificial Intelligence.

A. OVERVIEW

This chapter will survey how the United States and China, as two AI superpower navies, are adopting automation and AI tools and where their naval ISR falls along the Rogers' S-Curve of technological adoption. Specifically, it attempts to answer the following two main questions: How are the two AI superpower navies adopting automation for naval ISR in the domains of space, cyberspace, air, sea, and undersea? The purpose of this chapter is to develop a strategy and design method to adopt AI for naval ISR to stay on a healthy and competitive path for innovation.

This chapter will begin by discussing AI and automation today for both USN and PLAN through the step-by-step process developed from chapter 3. In this qualitative research methodology, there will be three main parts: First, I will discuss the various intelligence

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[146] Patrick Tucker, "Pentagon to Adopt Detailed Principles for Using AI," *Defense One*, February 18, 2020, https://www.defenseone.com/technology/2020/02/pentagon-adopt-detailed-principles-using-ai/163185/.

domains within which automation and AI are used for ISR: IMINT, SIGINT, OSINT, MASINT, HUMINT. Second, I will discuss the narrative and vision between the two naval leaderships. Third, I will select examples of automation and AI capabilities from each ISR domain: cyber, air, land, surface, and undersea.

B. DISCUSSION OF INTELLIGENCE AND TECHNICAL CAPABILITIES

Automation represents an important emerging military technology and network infrastructure across the main disciplines of intelligence. There are five necessary ways of collecting intelligence that fuel automation in naval ISR, called "intelligence collection disciplines" or the "INTS" (see Figure 9).

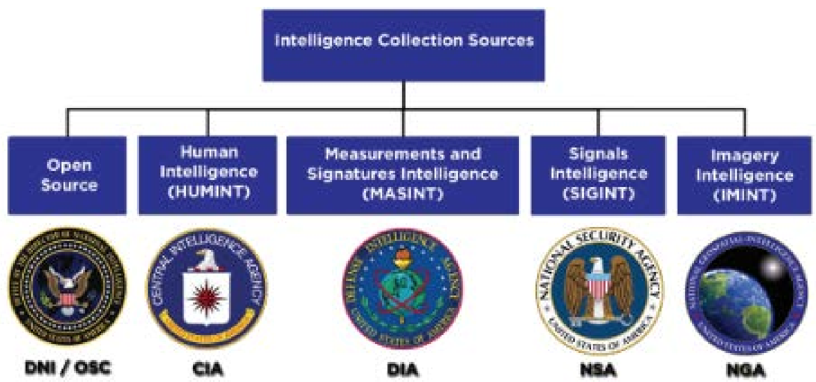

Figure 9. Intelligence Collection Capabilities for ISR[147]

Open Source information is derived from publicly available information. Human Intelligence is the collection of information from human sources; Measures and Signals Intelligence is the collection discipline concerning weapons, overhead and airborne imagery, telemetry, and electronic intelligence. Signals Intelligence is the collection and interception of electronic transmission from communications, electronic, and foreign instruments that can be collected from ISR platforms. Lastly, Imagery Intelligence refers to the collection and analysis of

[147] Source: Naval War College Library.

imagery, or photos, and geospatial information.[148] Each intelligence agency has authorization and responsibility for each of the intelligence discipline and are key organizations to understand and consult with to improve collection, analysis and dissemination processes for ISR activities. Figure 10 depicts examples of manned and unmanned systems necessary for ISR collection from intelligence community satellites to underwater arrays.

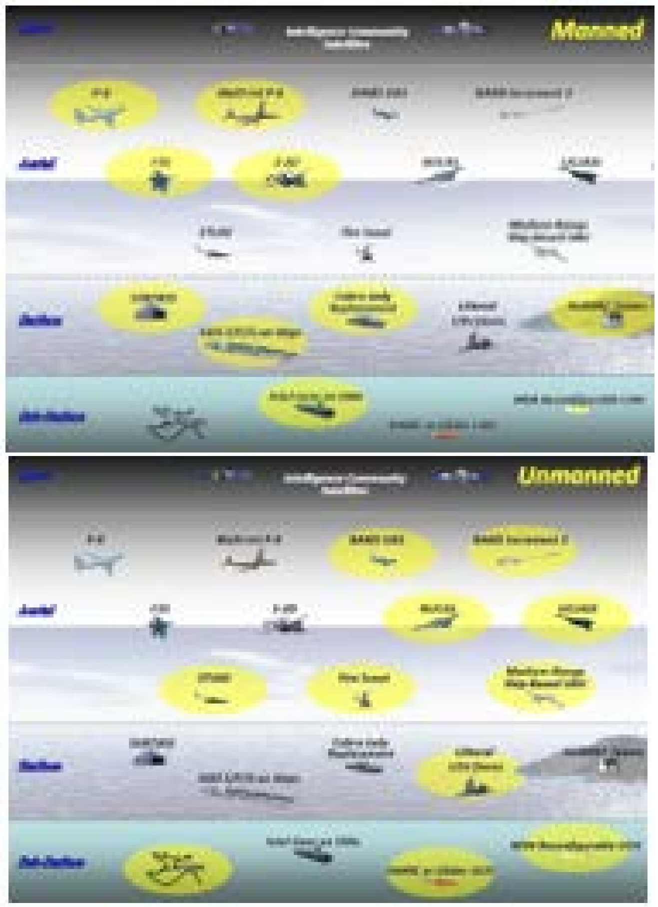

Figure 10. Manned and Unmanned Naval ISR platforms[149]

[148] Naval War College Library, "Intelligence Studies: Types of Intelligence Collection," Intelligence Studies Research Guide, March 5, 2020, https://usnwc.libguides.com/c.php?g=494120&p=3381426.

[149] U.S. Navy, "US Navy Maritime ISR Roadmap: Industry Day" (2010 Navy Information Dominance Industry Day, Heritage Conference Center, Chantilly, VA, June 22, 2010), https://www.afcea.org/mission/intel/documents/IndustryDay-Kraft.pdf.

Active and passive sensors are two types of remote sensing. Active sensing means that the "sensor emits and subsequently receives energy," to scan, detect, and then measure the radiation that is reflected or backscattered from the object.[150] Active sensing is analogous to a cellphone that when turned on and sending text messages reveals the location of the cellphone. Satellites represent the critical part of the sensing process. When naval ISR platforms are operating at sea, satellites are the sole means to connect. Two disadvantages of active sensing, however, include giving away the radar's location and the possibility of experiencing radio frequency or light interference.

While active sensing carries these vulnerabilities, passive sensing merely receives, detects, and tracks information or objects by processing reflections from objects of illumination in the maritime and space environment, such as communications signals or broadcasts. Passive remote sensing utilizes third-party transmitters and the time of the signal sent and its signal reflected off an object occurs in a triangular fashion to locate a target. Passive systems use an automatic trigonometric function of a triangle that measures the time difference of arrival or time distance of arrival (TDOA) from the emitted signal and the receiving signal from the reflection of the object through radar or light.

Sensor systems are: Radar (Radio Detection and Ranging) and LiDAR (Light Detection and Ranging). Both types can determine the range to a target where the time delay between emitting a radio wave (the signal) and return (receipt) is measured to establish kinematics (i.e., time, location, speed, altitude, and direction) of an ISR platform. For example, an aircraft sends out pulses and then reflects off the earth's surface, which provides a position like GPS. LiDAR uses light (visible or infrared), both of which can provide elevation, range, and bathymetric surfaces.[151] LiDAR advanced technology allows for signals to penetrate water and produce terrain mapping. While the plethora of data collected for terrain mapping exceeds the cognitive load of a human being, these automation systems can fuse radar and LiDAR information within a computer to provide the best battlespace picture at a faster rate for decision-makers.

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150 Mark M. Lowenthal and Robert M. Clark, eds., *The Five Disciplines of Intelligence Collection* (Thousand Oaks, CA: CQ Press, 2015), 130.

151 Lowenthal and Clark, 130.

C. VISION AND STRATEGIC NARRATIVES: CATEGORIZE AND ANALYZE COMPETING NAVAL LEADERS

Western leadership has always had a keen eye and thirst to know and understand the adversary. Abraham Lincoln once said, "I do not like that man. I must get to know him better. I do not like that person, I must get to know them better."[152] While philosophers of military affairs like Alfred Thayer Mahan and Carl von Clausewitz were imbued with Western political thought, which drives the U.S. Naval leadership today, Sun Tzu's idea imbues with the ethos to translate Mao Tse-tung and the People's war content to the sea. This is important to understand in order to avoid "mirror imaging" sidestepping stereotypical assumptions about Chinese naval leadership and how they would conduct operations compared with the American way of naval warfare. This is a profound aspect of the art of war in the pursuit of knowledge: to know and understand the adversary; and, noticing "pattern of life" at sea and any divergences from the normal naval pattern of life.

1. U.S. Naval Leaders Pursue Automation and AI

To pursue the adoption of AI for naval ISR, policy, and doctrine are the first steps in implementing changes. Policy plays a key role in improving naval ISR. Prussian General and military theorist Carl von Clausewitz, in *On War*, stated that "war is nothing but the continuation of policy with other means."[153] United States Naval policy on ISR is promulgated in the 2017 Joint Publication 2-01.[154] Knowing the adversary or competitor requires the collection of information by ISR platforms and knowledge of what lies on the highways, or sea lanes. Naval ISR is an instrument to be used in times of war and peacetime where the sea is a highway, as Alfred Thayer Mahan put is, "over which men may pass in all directions…familiar and unfamiliar dangers of the sea, both travel and traffic by water" is easier and cheaper.[155]

152 Coenn, *Abraham Lincoln*.

153 Clausewitz, *On War*, 69.

154 See Joint Chiefs of Staff, *Joint Intelligence Support to Military Operations*, Appendix B-1.

155 Till, *Seapower*, 1.

CNO Mike Gilday and his predecessor Adm. John Richardson prioritized designs for maintaining maritime superiority and strategic direction toward GPC with "cyber sentries." Then-Acting Secretary of the Navy Mr. Thomas Modly stated in his memorandum SECNAV Vector 11, "Take seriously your own role as a guardian of the digital information…Everyone in the DON enterprise must become a Cyber Sentry."[156] Mr. Modly believed the Navy personnel should guard their digital information and to do so as a sentry on guard, or as naval personal call it "on watch," but through computers. He sent a strong message that contributed to the notion that the future of naval affairs will be increasingly automated and to prepare in the meantime to become a guardian of cyber as if it were a physical post.

2. PRC Naval Leaders Pursue Automation and AI

The PLAN represents the party's naval force while being useful as an element of spy-craft. In fact, the PLAN politicizes the military because the party controls the military.[157] It is highly politicized because the party strictly controls the military. In the chapter, "Employment of Secret Agents," in Sun Tzu's book, *Art of War*, he states, "Hence it is only the enlightened ruler and the wise general who will use the highest intelligence of the army for purposes of spying and thereby they achieve great results. "Spies are a most important element in water because on them depends an army's ability to move."[158] When necessary, Chinese naval leadership can use ISR as spies in support of maneuvering naval forces while building and modernizing its forces.

3. Chinese Naval Modernization: String of Pearls and the New Maritime Silk Road

While the United States has continually modernized its navy over the last 200 years, China is only now beginning seriously to modernize its naval power. In 2004, defense contractor Booz Allen Hamilton (BAH) coined the term "String of Pearls" in a report to the

156 Thomas B. Modley, "SECNAV Vector 11," official memorandum (Washington, DC: Secretary of the Navy, February 14, 2020).

157 McGregor, "5 Myths about the Chinese Communist Party."

158 Sun Tzu, *Art of War*, trans. Samuel B. Griffith (Oxford, UK: Clarendon Press, 1964), 149, https://suntzusaid.com/book/3/18.

Office of Net Assessment for the DOD to describe China's long-term strategy to build partnerships from the Middle East to the South China Sea. China's new maritime silk road plan increases the PLAN's capabilities to improve naval ISR through a "String-of-Pearls" strategy.[159] Since 2008 PLAN has developed its antipiracy operations and exercises in the Gulf of Aden—its first naval operation beyond China's periphery to expand its interests in the far seas.[160] Despite China's lack of historical naval development, they are rapidly catching up to the U.S. Navy maritime superiority on the global stage.

PLAN leaders were once open to a division of labor across the Pacific to avoid future miscalculations or incidents at sea. Since 2006, then-Commander of the PLAN Vadm. Wu Shengli called for safeguarding and securing China's maritime rights, interests—near and abroad—and international sea lines of communications (SLOCs). Consequently, Admiral Wu led a major shift in naval operations to extend the PLAN navy beyond the littorals in the Pacific and the Indian Ocean. In May 2007, he proposed to then-Commander of PACOM Adm Timothy Keating, a division of labor where PLAN would defend the waters west of Hawaii and U.S. Pacific Fleet would protect the Pacific east of Hawaii.[161] Chinese naval leaders desired to divide the Pacific Ocean and defending it between PLAN and USN naval assets. The PLAN's leadership aspires to achieve great results through a layered defense using AI and ISR platforms to increase awareness of the maritime battlespace.

Although "dividing and conquering" seemed fit for defending international waters together, this was not the priority of the U.S. CNO. On July 9, 2019, then-CNO Richardson and current PLAN Commander Vadm. Shen Jinlong agreed on "reducing strategic, operational and tactical risk between the two navies to minimize the possibility of any

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159 Jessica Drun, "China's Maritime Ambitions: A Sinister String of Pearls or a Benevolent Silk Road (or Both)?," *Center for Advanced China Research Blog* (blog), December 5, 2017, https://www.ccpwatch.org/single-post/2017/12/05/China%E2%80%99s-Maritime-Ambitions-a-Sinister-String-of-Pearls-or-a-Benevolent-Silk-Road-or-Both.

160 Drun.

161 S. Mahmud Ali, *China's Belt and Road Vision: Geoeconomics and Geopolitics* (Cham, Switzerland: Springer International Publishing, 2020), 275.

misunderstanding or miscalculation" over video teleconference.[162] This dialogue indicates that the U.S. priority is safety and risk reduction and while dividing the labor of naval defense across the Pacific might be a mechanism to keep safety, it was not implemented by PLAN or the USN. Automating the amount of information flow and adopting AI analytical tools for relevant and accurate results can help shape and attain the goals that both navies are competing for.

D. PLAN ISR AND AI 2020: EXAMPLES OF ADOPTING AUTOMATION AND AI

This section explores a collection of automation and AI application examples related to naval ISR used by the PLAN. This exploration and analysis will encompass Over-the-Horizon (OTH) radar, Global Positioning System (GPS) and satellites used for receiving and analyzing radar signals, the *Dongdiao*-class spy ship, autonomous undersea vessels (AUVs) for anti-submarine warfare, the advantageous use of social media and hacking, and undersea sonar "listening" devices. Part of the analysis will describe where the PLAN situates along the S-curve of technological adoption.

1. PLAN's AI Strategy and Development Plans

The PRC and PLAN leadership are aggressively AI. On October 23, 2018, at the Beijing Xiangshan Forum, senior executive of NORINCO—China Ordnance Industries Group Corporation, China's third-largest defense company—Zeng Yi said in a speech that there will be no people fighting in the future battlegrounds and by 2025, lethal autonomous weapons would be a commonplace because of the increasing use of AI.[163] In 2016, Google's deep-learning system AlphaGo defeated the South Korean *weiqi* world champion Lee Sedol. After its victory, the program was re-named AlphaZero, which was a "break-through" technology and surpassed the inflection point of the S-curve of technological adoption

[162] Chief of Naval Operations Public Affairs, "CNO Holds Video Teleconference with Chinese Counterpart Vice Adm. Shen Jinlong," Navy News Service, July 9, 2019, https://www.navy.mil/submit/display.asp?story_id=110159.

[163] Gregory C. Allen, *Understanding China's AI Strategy: Clues to Chinese Strategic Thinking on Artificial Intelligence and National Security* (Washington, DC: Center for New American Security, 2019), https://www.cnas.org/publications/reports/understanding-chinas-ai-strategy.

because it incorporates analysis of past recorded games and data from the computer playing itself.[164] This is an exemplary technology that became even more attractive to the military to employ both deep learning and neural networks as automation tools for naval ISR.

The major plans and timelines illuminate Chinese organizational structure and with Three- or Five-Year Plans. In Mao Tse-tung ‘s “Problems of Strategy in China’s Revolutionary War,” the first chapter revolves around the laws of war being developmental at all levels in conjunction with China’s Five-Year Plan.[165] The latest version of this plan specifies a major scientific and technological infrastructure construction program through 2020 (see Table 5). Research for defense and strategic emerging technologies will likely continue to increase precision and range for Dragon Eye (Type-346) phased-array radar and its associated 3D air search radar “Top Plate” and therefore, expand the capabilities of the air and surface range for identification on future “mobile airbase.”[166]

Table 5. 13th Year Plan: PLA’s Defense, Dual-Use Plans, Science and Technology Strategies [167]

Name (English)	**Name (Chinese)**	**Issue Date**	**Sector/Area**	**Time Span**	**Responsible Agencies**
836 High-Technology Research and Development Plan (863 Plan) Civilian Component	国家高技术研究发展计 划(863 计划)	March 1986	Strategic technologies	1986–present	MOST, COSTIND/ SASTIND, PLA GAD
New High-Technology Weapons Plan (995 Plan)	新型高科技武器计划 (995 计划)	1999	Defense technology	1999-present	Central Military Commission (CMC), PLA GAD
2006-2020 Medium- and Long-Term Defense Science and Technology Development Plan (MLDP)	国防科技工业中长期科学和技术发展规划纲要(2006–2020)	May 2006	Defense Research & Development	2006-2020	COSTIND/ SASTIND
Civilian Explosives Industry Development Plan (2016–2020)	民用爆炸物品行业发展规划（2016－2020年）	October 2016	Explosives	2016-2020	MIIT

164 John Arquilla and Peter Denning, “Automation Will Change Sea Power,” *Naval Institute Proceedings* 145, no. 6 (June 2019): 34.

165 Tse-tung, *Problems of Strategy in China’s Revolutionary War*.

166 Kirchberger, *Assessing China’s Naval Power*, 211.

167 Koleski, *The 13th Five-Year Plan*, 41–43.

With support from President Xi Jinping, the Belt and Road Initiative (BRI) leverages global support and thus increases the need for ISR at sea (Figure 11). In 2013, BRI was designed for China to partner with Central Asia, the Middle East, Africa, and Europe to build and rent out ports by building infrastructure in over 30 countries (i.e., rail lines, roads, bridges, oil and gas pipelines, and port facilities).[168] Both the government and private investors, such as Silk Road Fund and the Asia Infrastructure Investment Bank (AIIB), fund the Chinese government and its BRI at an estimated $200 billion, which is projected to reach $1.2 to $1.3 trillion by 2027, according to Morgan Stanley.[169] The goal is to gain worldwide public support and acceptance of China's maritime plans in exchange for building infrastructure in over 30 countries and use automated systems to communicate.

168 The Belt and Road Initiative is the latest term in a series of terms to describe China's global infrastructure building and trade initiative. Other terms used are One Belt, One Road (OBOR), the Maritime Silk Road, the Economic Belt, the Silk Road Economic Belt, and the 21st Century Maritime Silk Road. While this list is not all-encompassing, these terms are often used interchangeably and are used to describe the same phenomena. The term Belt and Road Initiative is the most recent term used by China and will be used throughout this thesis

169 Andrew Chatzky and James McBride, "China's Massive Belt and Road Initiative," Council on Foreign Relations, January 28, 2020, https://www.cfr.org/backgrounder/chinas-massive-belt-and-road-initiative.

Figure 11. China's New Silk Road Called "String of Pearls" to Build and Expand Ports and Industrial Parks Across Southeast Asia, Including Sri Lanka, Kenya and Greece[170]

China's Anti-Access/Area-Denial (A2/AD) doctrine relies upon strategic surveillance provided through a three-layer defense strategy designed to control maritime approaches (Figure 12).

[170] Source: Jeremy Page, "China Sees Itself at Center of New Asian Order: Beijing Builds Roads, Pipelines, Railways and Ports to Bind Itself to Region," *Wall Street Journal*, November 9, 2014, https://www.wsj.com/articles/chinas-new-trade-routes-center-it-on-geopolitical-map-1415559290.

Figure 12. China's Anti-Access Area Denial Defensive Layers[171]

The first, outer-most, layer includes anti-ship ballistic missiles, diesel, or air independent propulsion (AIP) submarines, and Over-the-Horizon Radars (OTHR).[172] The second layer consists of long-and mid-range aircraft (with or without weapons) and submarines for strategic messaging, which can operate beyond China's periphery. The third, inner-most layer, is closer to the littoral region and combines all ISR navy, air, land, and sea platforms. The geographical constraint from neighboring countries represents the main disadvantage for China, specifically, Taiwan, the Ryukyu (Japanese) archipelago, northern Philippines, and Borneo.[173]

[171] "What Is Anti-Access/Area Denial (A2/AD)?," Missile Defense Advocacy Alliance, accessed February 27, 2020, https://missiledefenseadvocacy.org/missile-threat-and-proliferation/todays-missile-threat/china-anti-access-area-denial-coming-soon/.

[172] Anti-Access/area denial (A2/AD) strategic concepts were first used by the U.S. DOD 2001 Quadrennial Defense Review (QDR), and in 2018 was replaced with the National Defense Strategy (NDS). See Office of the Secretary of Defense, Quadrennial Defense Review, (Washington, DC: U.S. Department of Defense, 2010), 31–33.

[173] China's three-layer defense strategy caused U.S. strategy and policy to develop the 2010 Quadrennial Defense Review report as a national defense response.

2. PLAN Uses Automation to Test Its First Laser System Against U.S. P-8 Poseidon

PLAN strategies above exemplify its mission and capability to adopt automation sensors for situational awareness. On February 17, 2020, PLAN *Luyang* III-class destroyer (Type 052D) reportedly lased a U.S. Navy P-8 Poseidon maritime patrol ISR aircraft assigned to the VP-45 squadron about 329 nautical miles west of Guam in the Philippine Sea. This was the first reported instance of a Dragon-Eye radar tested against its main competitor, the U.S. Navy. This radar technology aligns with its China's 995 Plan and potential future execution of laser and explosive technologies, which naval ISR automation can identify, detect, and counter-lase faster than a human operator.

3. Modernizing PLAN Aircraft Carrier

The modernization of naval China's forces, including aircraft carriers, will continue automating naval warfare. In 2012 at the 18th Party Congress, then-President Hu Jintao called for China to become a "maritime power."[174] In April 2018, President Xi-Jinping echoed this vision and stated that "the task of building a powerful navy has never been as urgent as it is today."[175] China's 2019 Defense White Paper states:

> The PLA Navy (PLAN) has extended training to the far seas and deployed the aircraft carrier task group for its first far seas combat exercise in the West Pacific. It has organized naval parades in the South China Sea and the waters and airspace near Qingdao, and conducted a series of live force-on-force exercises codenamed Mobility and systematic all-elements exercises.[176]

PLAN's modernization and extended sea training, live-fire exercises, and red-versus-blue exercises with its aircraft carrier task group indicate great improvements in its automation capabilities. In unit level execution, the *Luyang II*–class (Type 052C) destroyer *Haikou* engaged a floating target with surface guns by using both radar and optical

[174] China Power Team, "How Is China Modernizing Its Navy?"

[175] China Power Team.

[176] Cordesman, *China's New 2019 Defense White Paper*, 3.

guidance.[177] According to Zhang Junshe, a senior researcher at the PLA Naval Military Studies Research Institute, *Liaoning* carrier operations "fired more than 10 air-to-air, anti-ship and air defense missiles" and used air defense radar to hit targets at sea with both Chinese destroyers, frigates, one replenishment ship, and one attack submarine in the Bohai Gulf, which is west of the Korean peninsula.[178] This trend indicates that the PLAN will likely continue to mimic the U.S. Navy's actions in the far seas. This form of mimicking, or "mirror imaging," is a type of cognitive trap the PLAN could be exemplifying. Mirror imaging is when human beings consciously or unconsciously assume the competitor thinks or acts like us because of how difficult it is to imagine someone else's perception being different from our own perception.[179]

4. China's Satellites and Technology Giants

Since the 1996 Taiwan Strait Crisis, when Chinese missile tests, intended to intimidate, were suspected of failing in flight, much has changed.[180] For example, Beidou, a navigational satellite system, is a centrally controlled satellite constellation that provides all-weather, accurate positioning, navigation and timing information, and leveraged by PLAN forces. The Beidou satellite constellation—manufactured by China Academy of Space Technology (CAST) and operated (China National Space Administration) CNSA—serves as an alternative to U.S. GPS satellites. It is interoperable with existing global navigation satellite systems (GNSS) and increases accuracy to precisely determine position, and includes 35 satellites as of 2020.[181] However, the China Academy of Space Technology CAST and operated by CNSA—which works across AI, surveillance, telecommunications, satellites, and the internet—discloses little open-source information

[177] Dale C. Rielage, "Chinese Navy Trains and Takes Risks," *Naval Institute Proceedings* 142, no. 5 (May 2016), https://www.usni.org/magazines/proceedings/2016/may/chinese-navy-trains-and-takes-risks.

[178] Zhao Lei, "CNS Liaoning Leads Live-Fire Drill," *China Daily*, December 16, 2016, https://www.chinadaily.com.cn/china/2016-12/16/content_27685144.htm.

[179] Zachary Shore, *Blunder: Why Smart People Make Bad Decisions* (New York: Bloomsbury USA, 2015), 162.

[180] U.S. GPS interference and the development of Global Positioning System (GPS) has proliferated, causing possible situations for signal interference to occur at sea or land.

[181] "BeiDou-3 Navigation Satellite System," Aerospace Technology, accessed March 7, 2020, https://www.aerospace-technology.com/projects/beidou-3-navigation-satellite-system/.

regarding policy, data, security, privacy, and censorship. By having radar stations, receivers, and increasing posts overseas, including in Djibouti and Australia, Beidou precisely collects and receives ISR data, and thereby provide precise positional data to PLAN operators at sea.

In an echo of Rogers' S-Curve, China was a late adopter of the global positioning system (GPS). Innovative nations who began developing GPS since its birth in 1973 include: U.S. GPS, Japan's Quasi-Zenith Satellite System (QZSS), the European Union's Galileo GNSS, Russia's Global Navigation Satellite System (GLONASS), and India's The Indian Regional Navigation Satellite System (IRNSS), (operationally called NavIC or Navigation with Indian Constellation).[182] The advantage of later adoption or being a laggard is observing, collecting, and analyzing the past lessons of other global powers building their own GPS system and then applying only the most advanced, successful satellite technical and business practices while avoiding past issues and mistakes other nations may have endured.[183]

Since 2006, Yaogan satellites launched by China have improved naval ISR and reinforced China's pursuit of great power status. According to the China Aerospace Science and Technology Corporation (CASC) and media outlets, on 29 July 2019, at 0347 UTC, China launched three Yaogan-30 (Weixing-30) remote-sensing, possible SIGINT satellites into Chuangxin-5 (CX-5) constellation using a Long March-2C carrier rocket. Since 2006, this Earth-observing satellite constellation in Lower Earth Orbit (LEO) can potentially detect ships via radio emissions and related technical tests. LEO satellites can triangulate multiple sources to enhance the procedures of automation faster in a near-continuous manner for naval ISR.

At the operational level, satellite technology boosts naval ISR capabilities to provide near-continuous ISR collection, exploitation, and analysis of signals that support the defense-in-depth strategy. At the tactical level of the Chinese satellite systems, the

[182] Mahashreveta Choudhary, "What Are Various GNSS Systems?," *Geospatial World* (blog), November 20, 2019, https://www.geospatialworld.net/blogs/what-are-the-various-gnss-systems/.

[183] Alexander Gerschenkron, *Economic Backwardness in Historical Perspective* (Cambridge, MA: Harvard University Press, 1962).

"architecture of 12 satellite constellation suggests that the purpose is to achieve a near-continuous ELINT surveillance of the regions between 35 degrees North and 35 degrees South Latitude" to detect and locate incoming adversaries from its littoral waters through various access routes from the Indian to Pacific Oceans, according to the International Strategic and Security Studies Programme.[184]

5. Automation for Long-Range and Early Warning: Joint Over-the-Horizon Radar

PLAN integrates long-range surveillance with its over-the-horizon backscatter (OTH-B) radar to provide long-range, 24/7 persistent coverage (see Figure 13). According to Janes, an intelligence and consultant company for defense and national security sectors, this conventional radar coverage extends up to 1,350 to 1,889 nautical miles (2,500 to 3,500km), but is limited by the horizon, or curvature of the earth, and atmospheric conditions.[185] OTH-B allows both the PLAN and the PLA to collect quality data from China while also leveraging the data for early indicators of where the U.S. Navy could potentially maneuver next (i.e., South China Sea, East China Sea, North Sea, or head straight to the Persian Gulf). OTH-B is an automated tool that represents a strategic advantage over the U.S. Navy and assisted by reconnaissance satellites.

[184] S. Chandrashekar and N. Ramani, *China's Space Power & Military Strategy – the Role of the Yaogan Satellites*, ISSSP Report No. 02–2018 (Bangalore, India: International Strategic and Security Studies Programme, National Institute of Advanced Studies, 2018), 2, http://isssp.in/wp-content/uploads/2018/07/Chinas-Space-Policy_July2018.pdf.

[185] Andrew Tate, "China Integrates Long-Range Surveillance Capabilities," *Jane's Intelligence Review*, November 1, 2017, Janes.

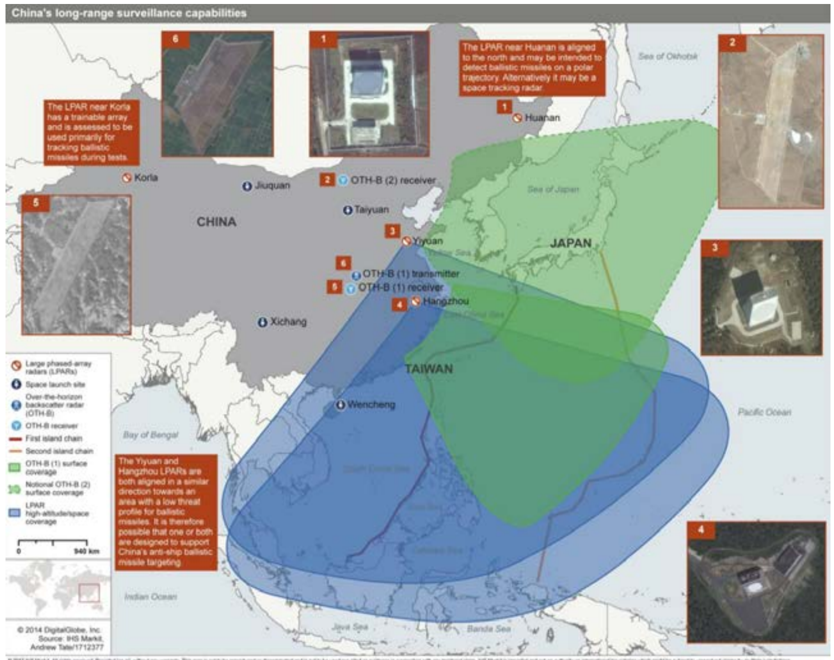

Figure 13. China's Long-Range Surveillance Capabilities Possibly Extend to Guam. Quality or Discrimination of Specific Class, Types, or Accurate Tracks is Undetermined[186]

In favorable atmospheric and other weather conditions, this High Frequency (HF) signal can possibly detect incoming naval platform as far from the Chinese coast as Guam and triangulate a possible position using China-owned Beidou satellites to locate, identify and track maritime or naval platforms with radar technology, as depicted by the large blue swath (see Figure 13). This automation system, though not intelligent, provides a highly competitive edge and strategic defense against incoming ballistic missiles.

Employing the S-curve, the PLA and PLAN OTH capabilities falls within the early adopters group. In 1945, the Harvard economic historian Professor Alexander Gerschenkron expressed the notion of "economic backwardness."[187] His notion exemplifies "the tendency on the part of backward countries to concentrate at a relatively early point of their industrialization on the promotion of those branches of industrial

[186] Source: Tate.

[187] Gerschenkron, *Economic Backwardness in Historical Perspective*.

activities" with rapid technical productivity.[188] China's "backwards strategy" to adopt specific ISR technologies releases tension from pre-industrialization conditions and waits for industrialization to overcome existing obstacles or technological challenges within an already progressing and industrial environment. Other nations that have adopted and exercise OTH capabilities: U.S. Skywave Radar, Australia's Jindalee Operational Radar Network (JORN), France's New Transhorizon Decametric System Applying Studio Methods (NOSTRADAMUS), Russia's Container, and Iran's Sepehr.[189] Few details are known of these systems; however, the transmission of these radars can cause radio frequency interference.

6. Future of Anti-Submarine and AI

To date, the PLAN has deployed and experimented with autonomous surface vessels and unmanned underwater vehicles. Notably, the *Sea Wing*, or Haiyi, glider, developed by the Chinese Academy of Sciences (CAS) Shenyang Institute for Automation, has high potential to be used as a stealthy underwater spy drone to scour the seas within the First Island Chain at a depth of 3.2 nautical miles (6 km). The Sea Wing is a buoyancy-driven autonomous underwater vehicle (AUV).[190] Sea Wing is advantageous because of its low acoustic signature and its ability to traverse large deep blue water with minimal energy to depths of 11,034 meters along the Marian Trench.[191] Sea Wing has been known to operate in the South China Sea and the Indian Ocean to support special operations by detecting submarines and gathering both intelligence and bathymetric data for future

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[188] Maurice Dobb, "Economic Backwardness in Historical Perspective: A Book of Essays. by A. Gerschenkron," *Economic Journal* 74, no. 296 (December 1964): 1001–1003, https://doi.org/10.2307/2228863.

[189] Engineers Australia, *Jindalee: Over-the-Horizon Radar* (Barton ACT: Engineers Australia Engineering Heritage Victoria, 2016), 64–70, https://portal.engineersaustralia.org.au/system/files/engineering-heritage-australia/nomination-title/Jindalee.Nomination.V14.June%202016.pdf.

[190] Jamie Seidel, "Beijing Releases 12 'Haiya' Sea-Wing Surveillance Drones into the Disputed South China Sea," News Corp Australia Network, July 28, 2017, https://www.news.com.au/world/beijing-releases-12-haiya-seawing-surveillance-drones-into-the-disputed-south-china-sea/news-story/16bd0faf5195f31fdc7c3afeb5b826c2.

[191] Stephen Chen, "PLA Navy Eyes China's Deep-Sea Underwater Glider After Successful Test Shows It Rivals U.S. Vessel," *South China Morning Post*, September 1, 2016, https://www.scmp.com/news/china/article/2012137/pla-navy-eyes-chinas-deep-sea-underwater-glider-after-successful-test.

operations.[192] The risk of deploying AUVs occurs if a competitor seizes the drone in territorial or perhaps international waters, as in mid-December 2016 when China seized an America underwater drone.[193] PLAN has the advantage of collaborating with Chinese universities to develop and invest in automation for undersea warfare.

In the polar regions, the PLAN has taken advantage of AI as a more viable option for operating in harsh and sub-freezing conditions. In November 2017, PLAN deployed the Snow Dragon in company with the unmanned M80B seabed boat in an Antarctic expedition and through Ocean Alpha Co. PLAN's adoption of AI and advanced algorithms in Sea Wing and Snow Dragon provides the strategic advantage in two distinct and opposite environments for remote sensing. AI ensures accuracy in the undersea vessels sailing route with GPS mapping to avoid obstacles. In freezing environments, M80B does not freeze until it is at -35℃ and can withstand this harsh condition.

PLAN's growing fleet with unmanned and autonomous vessels and swarm technologies represents current attempts to augment maritime swarm tactics both undersea and in the polar regions. For instance, PLAN attempts to aid in marine swarm tactics through a project for naval ISR called the 912 Project. In 2018, 56 miniature unmanned boats released a video demonstrating coordinated boat swarm tactics off the coast of the Wanshan Archipelago in the South China Sea.[194] These special operations swarm tactics and undersea ISR platforms are in line with the 912 Project, a classified project to develop military underwater robots developed by Shenyang Institute of Automation of the Chinese Academy of Sciences, which coincides with China's hundred-year anniversary of the Chinese Communist Party in 2021. From an "undersea great wall" in the polar regions to the Mariana-Trench, the 912 Project improves maritime domain awareness in an innovative way for swarming technologies.

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192 Elsa B. Kania, "The AI Titans' Security Dilemmas," *Governance in an Emerging New World*, no. 218 (October 29, 2018), https://www.hoover.org/research/ai-titans.

193 Lyle J. Goldstein, "Robot War in the South China Sea?," *National Interest*, October 11, 2018, https://nationalinterest.org/feature/robot-war-south-china-sea-33146.

194 Phillip Smith, "Oceanalpha Debuts Maritime Drone Swarm," Drone Below, June 6, 2018, https://dronebelow.com/2018/06/06/oceanalphas-debuts-maritime-drone-swarm/.

7. China's Observer Corps and AI Stalkers

PLAN utilizes its special surveillance vessels like *Dongdiao* and *Dadie* Auxiliary General Intelligence (AGI) ships and Chinese Maritime Militia (CMM) as automated observers for early warning. The PLAN intelligence ship has the electronic capability to use AI to identify and locate maritime vessels or aircraft. The data-absorbing machine, PLAN's *Dongdiao*-class AGI (Type 815G) spy surface ship, is purpose-built to intercept electronic and communications signals.[195] In May 2018, the Chinese navy, and specifically intelligence gathering ships like *Dongdiao*, were disinvited from participating in Rim of the Pacific (RIMPAC) exercises, in response to China weaponizing the SCS.[196] Joint naval exercises represent the optimal and complex tactical intelligence event for the PLAN to observe, gather data electronically, and then use AI to analyze other navies in action.

As later adopters, PLAN has taken advantage of fusing the strategic design of an observer corps with automation and AI at sea with automation systems onboard ISR platforms to give some degree of advanced warning of adversary approach or attack. During WWII, the Royal Observer Corps, traditionally the eyes and ears of the RAF—a powerful partner to the Chain Home radar installation along the British coast—were designed to listen to the sound of incoming German aircraft using parabolic concrete sound mirrors and make visual sightings, both of which were then transmitted from Observer Posts to Group and Sector controls.[197] PLAN has transcended this idea of an augmented observer complex system for early warning by utilizing CMM as possible observers, South China Sea islands as observer posts, and people using social media to exploit the possible location of naval vessels at sea.

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[195] In the July 2019, the Chinese surveillance ship reportedly monitored the international and joint Talisman Saber naval war games, which involved American, Australian, and Japanese naval forces.

[196] Ryan Pickrell, "A Chinese Warship Is Believed to Have Been Sent to Spy on War Games between the U.S., Australia, and Japan," *Business Insider*, July 7, 2019, https://www.businessinsider.com/australia-tracks-chinese-spy-ship-watching-talisman-saber-war-games-2019-7.

[197] Nick McCamley, *Cold War Secret Nuclear Bunkers: The Passive Defence of the Western World During the Cold War* (Barnsley, South Yorkshire: Pen and Sword Military, 2007), 123.

8. Chinese Maritime Militia (CMM) "Little Blue Defenders"

China uses CMM vessels to develop its great maritime power. As an external force and security force, CMM can be leveraged as a political tool to enforce disputed maritime claims of its islands, rapid responders toward contingencies at sea, and normalizing administrative control of the seas along the nine-dash line.[198] CMM reconnaissance detachments can serve as early warning networks with 32 "mother ships" acting as third-party nodes of surveillance in both low-intensity and high-intensity conflicts. The "Little Blue Defenders" help China dominate in AI with its overt ability to collect data and information around disputed islands (i.e., Spratly Islands, Scarborough Reef, Paracel Islands, Senkaku Islands) and provide the data to the PLAN.

Due to the multi-role and nature of its special mission, the use of CMM falls within the category of later adopters. CMM serves as a strategic asset in peacetime and to preserve maritime rights and protect local fishermen. In a high-intensity conflict, CMM can support larger PLAN forces with mine laying, fuel and food replenishment, deceptive transportation of troops and ammunition, concealment, sabotage, etc. "Little Blue Defenders" strongly improve ISR coverage, potential gaps, and can serve as a targeting asset to report signals or electronic early warning of incoming competitors or contacts of interest at sea. The concept of using non-naval warships as early warning assets was also employed by Russian fishing trawlers during the Cold War. CMM is not innovative, but the PLAN has a unique advantage to easily operate in the littorals, along one coastline.

9. Social Media and Open Source

In social media and unclassified sources, PLAN servicemember using social media platforms is now subject to AI and automated bots monitoring their text messaging, social media posts, or geo-tracking their military movements. According to a consultant at Intelligent Biology and scholar at Georgetown University Medical Center Nicholas Write, "in order to prevent the system from making negative predictions, many people will begin to mimic the behaviors of a 'responsible member of society' to improve social control and

[198] Dennis Blasko, *The Chinese Army Today*, 2nd ed. (Thousand Oaks, CA: Routledge, 2012), 23.

change the way they think." This massive surveillance AI tool can be used to exploit the location or the deployment cycle of naval operations when PLAN servicemembers are posting or geotagging on Facebook, Instagram, or Twitter.[199]

China can track U.S. naval forces through open-source sites that collect AIS data or filtering through Facebook and Instagram posts of sailors preparing to deploy. For example, in Marine Traffic, a public website, one can type and search "US Gov" or "US GOV VLS." China can leverage AI tools like Marine Traffic to locate U.S. naval surface vessel its Automatic Identification System (AIS) locators are turned on.[200] China can leverage this data by finding the unique maritime mobile service identity (MMSI) and Google search MMSI 303891000.

10. PLAN Cyberspace Copy-Cats

China's role in cyberspace espionage occurs through state-sponsored Advanced Persistent Threat (APT) groups.[201] APT groups focus on and are designed to steal data, disrupt operations, destroy infrastructure while collecting and prioritizing relevant information. APT1 cyber activities stem from the 2nd Bureau of the PLA General Staff Department (GSD) 3rd Department, also known by its Military Unit Cover Designator as Unit 61398. APT40, code name Periscope, targets countries of great strategic importance to China, like the United States. China dedicates about $14.9 billion (RMB 100 billion) to the Internet Investment Fund for Chinese Internet of Things and high-speed fiber optic cables, according to China's 13th Five-Year plan in the USCC annual report.[202] The evidence for IP theft and economic investment suggests that China is aggressive in its use

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199 Nicholas Wright, "How Artificial Intelligence Will Reshape the Global Orde," *Foreign Affairs*, July 10, 2018, https://www.foreignaffairs.com/articles/world/2018-07-10/how-artificial-intelligence-will-reshape-global-order.

200 "Marine Traffic Live Map," Marine Traffic, accessed March 5, 2020, https://www.marinetraffic.com.

201 FireEye Mandiant, *M-Trends 2019* (Milpitas, CA: FireEye Inc., 2019), https://content.fireeye.com/m-trends/rpt-m-trends-2019.

202 Katherine Koleski, *The 13th Five-Year Plan* (Washington, DC: U.S.-China Economic and Security Review Commission, 2017), 13, https://www.uscc.gov/sites/default/files/Research/The%2013th%20Five-Year%20Plan_Final_2.14.17_Updated%20%28002%29.pdf.

of cyber espionage.[203] On the other hand, the U.S. 2018 Cyber Security Strategy emphasizes that China is “persistently exfiltrating sensitive information from U.S. public and private sector institutions” and has responded with adopting automation and AI for naval ISR to outpace China and PLAN’s AI strategy.[204]

E. U.S. NAVY ISR 2020: ADOPTING AUTOMATION AND AI

Despite the PLAN’s efforts to modernize rapidly, the United States continues to be the world’s foremost naval force. American aircraft carriers represent “national command authority and warfighting Commanders-in-Chief with a flexible force to respond to a wide variety of international challenges…four and one-half acres of sovereign-and mobile-American territory that can project U.S. power whatever it might be required.”[205] The aircraft carrier constitutes a small and mobile American airport to sail and defend the seven seas and when deployed, the U.S. carrier strike groups can maintain its networks and rapidly respond to a crisis or in defense of international shipping with its naval network infrastructure. All of which makes an aircraft carrier an appealing target.

The U.S. Navy has continued to advance its network infrastructure within carrier strike groups and in a joint environment. In 2016, then-CNO Adm. Richardson proposed the Joint Concept for Access and Maneuver in the Global Commons (JAM-GC) to strategize and design countermeasures against PLA’s defense-in-depth threat.[206] The concept of network-centric warfare links today’s network systems in local and wide-area networks. Networks that link SSDS as a whole have three main components: Cooperative Engagement Capability (CEC), which is a virtual “spiderweb” of various networks to connect and share data; Navy and Marine Corps Intranet (NMCI), which is a localized ship-centric, encrypted network; and Link-16, which connects all of the systems.

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[203] FireEye Mandiant, *M-Trends 2019*, 3–20.

[204] Donald J. Trump, *National Cyber Strategy of the United States* (Washington, DC: White House, 2018), 2, https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Cyber-Strategy.pdf.

[205] Federation of American Scientists, “The Aircraft Carrier Plan.”

[206] Stephen Daggett, *Quadrennial Defense Review 2010: Overview and Implications for National Security Planning*, CRS Report No. R41250 (Washington, DC: Congressional Research Service, 2010), https://fas.org/sgp/crs/natsec/R41250.pdf.

While CEC is not specifically an ISR program, this is the vein of the naval anatomy and network-centric body that allows many Navy sensors—from space to undersea systems—to create an automated picture of the battlespace. The Navy's CEC has been successful in interconnecting multiple systems; from *USS John F. Kennedy* carrier battle group to today's *Nimitz*-class and the upcoming *Ford*-class carrier strike groups. For automation and U.S. naval ISR data, the foundational system to pay attention to is the Distributed Common Ground Station Navy (DCGS-N). DCGS-N combined with CEC, intranet, and Link-16 forms networks within networks that allow identification, classification, and targeting.

1. Ford-Class Aircraft Carrier: Aegis to SSDS Computers for AI

In today's *Ford*-class aircraft carriers, the U.S. Navy will keep the 50-year legacy Aegis computer system and advance its automation capabilities with a computer system called Ship's Self Defense (SSDS) automation. The U.S. Navy has selected Lockheed Martin's Ship's Self Defense System (SSDS) Mk 2 5 Systems Engineering Agent (CSEA) today for next-generation *Ford*-class aircraft carriers. While Lockheed Martin made an initial bid in August 2017, it did not issue a press release until two years later, in August 2019, which stated, "SSDS is a Combat Direction System that provides capability to defend against Anti-Ship Missile (ASCM) attacks…developed the Common Source Library (CSL) which enables efficient deployment of common software solutions across the Surface Navy, with variation techniques to customize for particular configurations."[207] However, despite this delay from initial bid to press release and launch, both the company and the DOD needed time and space to develop the product and increase the interoperability of a diverse list of AI software and applications into one system.

In adopting automation and AI across the Navy, pre-testing, and testing phases are essential phases to test compatibility between multiple networks and future software upgrades. For instance, the SSDS computer makes it easier for compatibility. This "plug

[207] "Future Warfighting Capabilities Secure with Lockheed Martin Engineering Experience," Lockheed Martin Newsroom, August 20, 2019, https://news.lockheedmartin.com/future-warfighting-capabilities-secure-with-lockheed-martin-engineering-experience.

and play" unified software automates within one program rather than multiple systems, which is like the concept of Microsoft or Apple products being compatible with in-house products. This is a key and critical computer program to consider adding to the pre-testing and testing phases when adopting emerging technologies across both naval ISR systems and branch ISR platforms.

The improved SSDS and HTI systems contribute to the Internet of Things (IoT) and suggest a continuous increase in automation in naval systems. The Hardware Technology Insertion (HTI) 16 infrastructure is a new software update to assist in battlespace awareness.[208] For air contact, the Enterprise Air Surveillance Radars automates tracking for human operators, according to Jim Sheridan, Vice President of Naval Combat and Missile Defense Systems at Lockheed Martin.[209] HTI updates for the *Ford*-class carrier will also be adopted on several other commissioned ships. SSDS Advanced Capability Build 20 (ACB 20) will be delivered to aircraft carriers and amphibious ships: USS George Washington (CVN 73), the amphibious assault ship *USS Boxer* (LHD 4) and the amphibious platform dock ships *USS San Antonio* (LPD 17) and *USS Fort Lauderdale* (LPD 28), according to *Seapower* magazine.[210] Of note, the only U.S. naval platforms not to receive this update are the *Zumwalt*-class guided-missile destroyers. Building and implementing a network infrastructure to encompass both SSDS and HTI signifies a "leap over" any possible chasm or "fall-off" point from early majority adopters and getting closer to the inflection point along the S-curve of technological adoption.

[208] Richard R. Burgess, "Four Navy Ships Set for Delivery of Newest SSDS Configuration," *Seapower*, January 14, 2020, https://seapowermagazine.org/four-navy-ships-set-for-delivery-of-newest-ssds-configuration/.

[209] Marty Kauchak, "Naval Channel SNA 2020: 'A Whole New Heat and Light,'" Mönch Publishing Group, January 15, 2020, https://monch.com/mpg/news/naval-channel/6606-sna-2020-lockheed-ssds-acb-20.html.

[210] Burgess, "Four Navy Ships Set for Delivery of Newest SSDS Configuration."

2. Reconnaissance Satellites: ELINT, SIGINT, and Ocean Surveillance

Reconnaissance satellites, combined with AI that automates detection and analysis of electronic signals, survey the oceans to identify and locate naval forces at sea at specified times. The time depends on when the reconnaissance satellites are overhead an area at a particular time. Satellites are categorized into four main orbits at specific altitudes: Low Earth Orbit (LEO) (372–621 miles), Medium Earth Orbit (MEO) (6,213—12,427 mi), High Earth Orbit (HEO) (310–29,825 mi), Geostationary (GEO) (22,236 mi), and Geosynchronous (GEOS) (22,236 mi). Each constellation has a capability and purpose that requires knowledge of three key capabilities: bandwidth, throughput capacity, and overhead or passing over a certain area and how frequently the satellite can pass over a specific area. Today, online companies develop AI to ingest and analyze data from radars and reconnaissance satellites to provide answers to these top three categories of required knowledge. In turn, open-source AI tools online provide a strategic advantage over China.

Human operators can leverage open-source commercial AI websites to possibly determine the Chinese satellite trajectory and when it could be above a target area. For example, the Chinese satellite constellation called Yaogan can be used online through the commercial company LeoLabs. LeoLabs has developed an algorithm for overhead sensing times and locations using open-source data and three privately owned land radars (Poker Flat Incoherent Scatter Radar (Alaska, USA), Midland Space Radar (Texas, USA), and Kiwi Space Radar (New Zealand).[211] Figure 14 shows the ability for anyone to view the website and view the orbital mechanics, available data, previous passes, next planned passes, recent state vectors, and other forms of metadata.

[211] "Three Ways to Use LeoLabs," LeoLabs Platform for Operators and Developers, accessed March 8, 2020, https://platform.leolabs.space/.

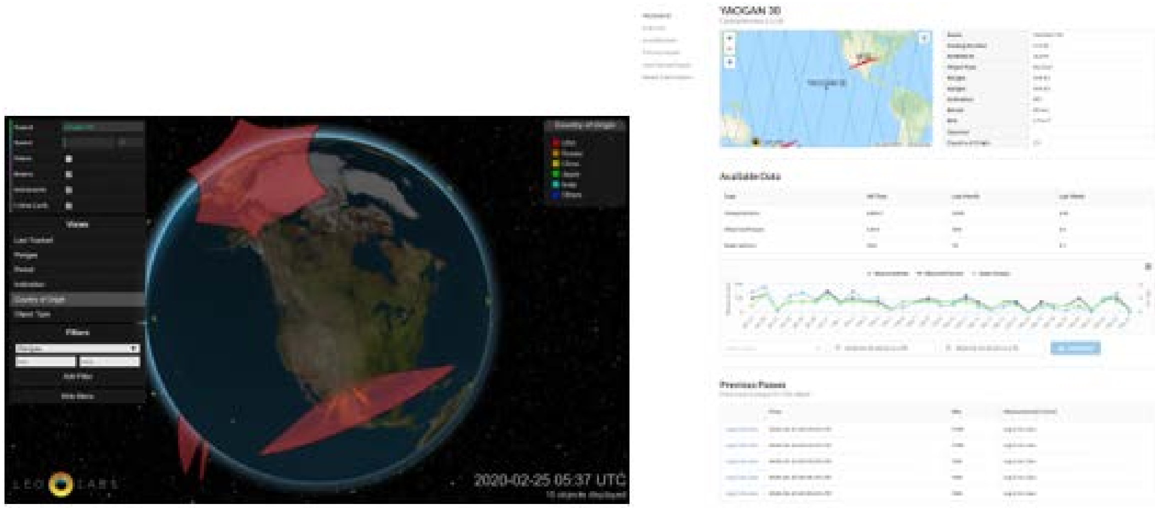

Figure 14. LeoLabs, Open-Source Private Company Designed to Provide Applications for Operating in Low Earth Orbit[212]

As placed on the S-curve, U.S. private companies fall within the categories of innovators and early adopters. This AI tool has specific algorithms that provide visual analytics to show the human operator location and tracking data from open-source information on Chinese satellites, such as the Yaogan constellation in LEO orbit (Figure 14). The available data includes metadata, particularly a satellite's name, catalog number, country, and observed passes. Notably, this is a sophisticated AI tool may be leveraged to proactively avoid open-ocean surveillance. Part of the adoption S-curve that is critical to achieving success is investing in a capability that will provide a return on investment; and thus, Department of the Navy, however, will have to purchase the data before using the software to use this AI tool.

Among these orbital reconnaissance satellites, to use AI tools, electronic signals can tell the identity of a platform based on its radar signature. ELINT is a means in which a machine and another machine sends signals to each other, and electronic signals are a type of SIGINT. The signal is the propagation of electromagnetic waves at specific frequencies. Each pulse has a signature or set of characteristics like a fingerprint which includes pulse width, pulse repetition frequency or pulse repetition interval, scan time, and

212 Source: "LeoLabs Platform for Operators and Developers."

scan type; this automation software tool can potentially identify and determine the characteristics of the signals. AI can automatically analyze low to high-frequency signals at a faster rate than human beings. This is important for quick analysis of signals collected by naval ISR platforms for decision-makers.

Electronic signals from active military radars illustrate how naval forces are operating. According to the Navy's Credentialing Opportunities Online (COOL) program, naval cryptologists analyze radar signals from worldwide technical ELINT data to support naval ISR and national intelligence priorities.[213] An automation ELINT tool called GALE-LITE can provide rapid retrieval of data, track animation, histogram, scattergram, and other analysis tools; "this information is used to design weapons to penetrate the enemy's defenses…electronic countermeasures to frustrate the enemy's weapons" in a vicious cycle.[214] The ability to gather intelligence via reconnaissance satellites can help better understand the other navy from short to long-range frequencies and ultimately, for early warning. Improvement to the adoption of an AI tool such as GALE can be upgrading or modifying notifications to make it user-friendly.

3. Long Range: Over-the-Horizon Backscatter Radar

Long-range early warning from OTH radar supports naval ISR in a global and multi-system strategic environment. The first long-range and passive operating system is the Army-Navy/FPS-118 Over-the-Horizon Backscatter Radar System (OTH-B) from the 1970s. OTH-B is used "for a frequency modulation/continuous wave (FM/CW) radar capable of detecting and tracking objects at over-the-horizon range."[215] The purpose is to provide long-range surveillance of aerial approaches to the United States. Specific automation and AI software include Kiwi SDR, which can detect OTH radars and then automatically analyzes the active or passive signals as far as over the Pacific Ocean. Figure

[213] Naval Reserve Intelligence Program, "Module 8—Intelligence Automated Data Processing (ADP) Systems: L. Gale Lite," in *Ready-for-Sea: Modular Course & Handbook* (Naval Air Station North Island, CA: Naval Reserve Intelligence Program, 1999), https://fas.org/irp/doddir/navy/rfs/part08.htm.

[214] Barnaby, *The Automated Battlefield*, 30–31.

[215] "AN/FPS-118 Over-The-Horizon-Backscatter (OTH-B) Radar," FAS Strategic Air Defense Systems, June 29, 1999, https://fas.org/nuke/guide/usa/airdef/an-fps-118.htm.

15 depicts how AI has been adopted for breaking apart each bit of a Chinese OTH signal: possible frequency, type (naval surface platforms) and duration of the signal.

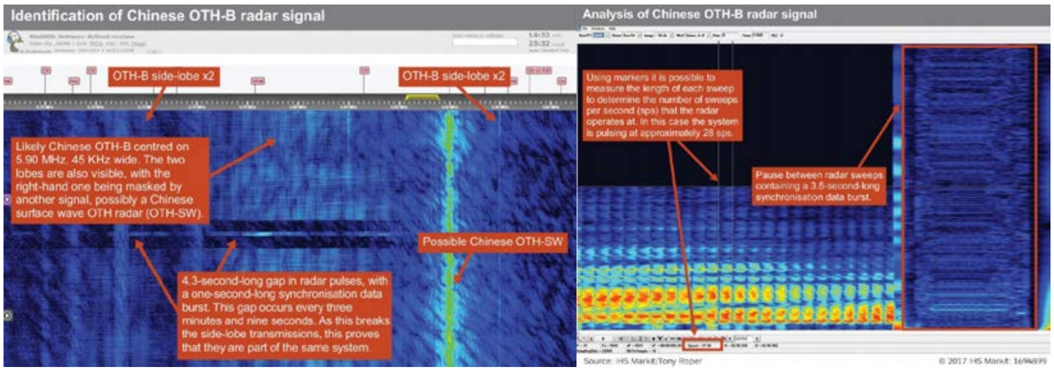

Figure 15. Kiwi SDR Automation Software Identifies Possible Chinese OTH-Backscatter Radar Signal Pulses and Analyzes the Frequency[216]

Kiwi SDR falls within the category of early innovation of a highly advanced nature. Building the codes to implement this software coupled with human operators having to learn how to use and understand this program signifies innovation and early adoption. Although the entire process of Aegis or SSDS collecting and analyzing data for possible target acquisition and be complete in a few thousandths of a second and no single human being, the analysis of long-range detection radars can benefit from AI tools such as the one used by the company Kiwi SDR.[217] Overall, the software helps human teams better determine a pattern or possibly detecting an anomaly. The technicalities or reviews on user-friendliness is unknown about the Kiwi SDR.

4. ISR Platforms and Laser Technology

High-altitude aircraft to aircraft and automated systems organic to the carrier provide strategic theater awareness off-board the ship (inorganic ISR asset). Inorganic ISR platforms onboard the aircraft carrier include the following: P-3 Orion and P-8 Poseidon provides high-altitude submarine-hunting capabilities with onboard detection and ability

216 Source: Tate, “China Integrates Long-Range Surveillance Capabilities.”

217 Barnaby, *The Automated Battlefield*, 32–33.

to drop sonobuoy listening devices (active and passive radars); EP-3 can collect signals emanating from other maritime platforms, Global Hawk are all inorganic assets and MH-60R for hunting submarines, E-2 Hawkeye provides air early warning with a massive disc-shaped radar to share data with other aircraft beyond the carrier; F/A-18 Super Hornet provides visual identification with sensor-to-shooter and targeting capabilities, and the E/A-18G Growler is the specialized version of the Super Hornet that provides tactical and electronic jamming. This complex mobile airport system that uses organic and inorganic automation allows the U.S. Navy to extend its reach to classify, identify, engage, and respond to crises or threats beyond a mere 200 nautical mile distance.

Lasers provide an organic naval capability designed to counter ISR against threats or naval platforms being lased but may cost more than it is worth. For counter-ISR, the U.S. Navy has developed and installed the first Optical Dazzling Interdictor, Navy (ODIN), laser weapon system to blind or disrupt unmanned aerial systems threatening U.S. forces (Figure 16).[218] This technology requires a high level of directed energy and power—sometimes enough to power a small city—with a low circular error probable (CEP) if automated calculation to send high directed energy is accurate. The probability of hitting a target manually can be extremely difficult and the system requires extensive locational data and in real-time from the ship's sensors. The major threat and necessity for AI within a computer system is to decrease the CEP while being able to react against other incoming threats. Other incoming threats can include future swarms of AUVs or countering other technologies that may lase ISR cameras or optic sensors.

[218] "Navy Leverages Workforce; Delivers C-ISR Capability Rapidly to Surface Fleet," Naval Sea Systems Command, February 20, 2020, https://www.navsea.navy.mil/Media/News/SavedNewsModule/Article/2089079/navy-leverages-workforce-delivers-c-isr-capability-rapidly-to-surface-fleet/.

Figure 16. Lockheed Martin's Optical Dazzling Interdictor, Navy laser Designed for Counter-ISR[219]

When refueling aircraft, AI software within semi-autonomous aircraft reduces human labor and provides surveillance capabilities on the maritime battlefield. Northrop Grumman's X-47B Unmanned Carrier Air System (UCAS) conducted its first flight in February 2011 and from 2012 through 2015 conducted touch and goes from *USS Harry S. Truman* and *USS George H.W. Bush.* Because of the iterative software tests, the first-ever airborne refueling between a Boeing 707 and UCAS occurred in April 2015 and the AI software inside this testbed became the new AI configuration for the Navy's MQ-25A Stingray. In addition to surveillance, because there are only nine air wings for 10 aircraft carriers, this brilliant automation example can offload human labor and extends the range of an F/A-18 Super Hornet beyond its 500 nautical mile range.[220] This AI-infused unmanned aircraft can conduct aerial refueling and surveillance, which will further automate naval warfare while extending the distance of naval aircraft range.

At sea, the fully autonomous ship "Sea Hunter" provides antisubmarine warfare capabilities with AI applications and is cheaper than the P-8 Poseidon. Sea Hunter, which was developed by DARPA and U.S. defense companies Leidos and Sonalysts, can patrol the maritime domain for up to 70 days and range of possibly 10,000 nautical miles, and

[219] Source: Harry Lye, "US Navy Deploys ODIN Counter-UAS Laser," *Naval Technology*, February 20, 2020, https://www.naval-technology.com/news/us-navy-deploys-odin-counter-uas-laser/.

[220] David Axe, "Stealth Refuel Drone: Meet the Navy's New MQ-25 Stingray," *National Interest*, March 12, 2020, https://nationalinterest.org/blog/buzz/stealth-refuel-drone-meet-navys-new-mq-25-stingray-132302.

only at $20 million per unit, according to The National Interest.[221] With one exception, this aircraft provides ISR to monitor Chinese submarine activity with less human labor and less in price.[222]

5. Cyberspace and Social Media

Social media improve naval ISR missions in terms of identifying, tracking, and locating naval platforms worldwide. For example, MarineTraffic and FleetMon, which automate ship tracking and maritime intelligence, are websites generated by AI programs to openly track radars actively emitting at sea (see Figure 17). The data from open-source companies are gathered from a network of coastal AIS-receiving stations, satellite receivers, and algorithms to identify, integrate, and track shipping, trade and logistics worldwide.[223] The algorithm within this analytical tool can show past tracks and background information. Purchasing the data in bulk can help fill the gap of unknowns and improve the quality of AI tools or resources.

Figure 17. Marine Traffic Tool Tracks Chinese Maritime Militia (Left), "Liaoning" CV-16 Operating in North Sea Fleet (Right)[224]

[221] Lyle J. Goldstein, "How China Sees the U.S. Navy's Sea Hunter Drone," *National Interest*, January 31, 2017, https://nationalinterest.org/feature/how-china-sees-the-us-navys-sea-hunter-drone-19264.

[222] One exception in which the vessel may not be able to withstand rough seas autonomously because it may damage the computer system and robot that would render it inoperable

[223] "Marine Traffic Live Map."

[224] Source: "Marine Traffic Live Map."

However, three major trade-offs are associated with this AI tool. First, maritime tracking algorithms cannot provide continuous ship tracking if AIS is not transmitting data or if the human operator does not have the exact name to search for a vessel. Second, increasing automation and associated radar systems, AIS can be active and useful for military tracking, particularly if one knows or can find the key name or MMSI is known or can be found. Third, data must be available, accessible, bought, or easily transferable through user-friendly databases or cloud-based services. Purchasing bulk data, integrating a mix of open-source AI software tools can benefit ISR tracking compared to using several separate resources.

The Navy, Special Forces and DOD writ large can utilize AI software, such as Primer.ai, to quickly filter through online documents regarding the current geopolitical situation and the competitors' intent, strengths, and weaknesses. The Silicon Valley-based AI software called Primer.ai reads and writes thousands of open-source documents with machine learning assistance. CEO and founder of Primer Sean Gourley, Vice President of Solutions Architect Ben Van Roo, and Director, National Security Group Brian Raymond have developed an AI-assisted organization, summarization, and report updates on global targets.[225] Key events, information, or tone are extracted among relevant documents. The overall strategy and purpose of this software can provide quick indications and warnings of the competitors next move based on thousands of open-source news, reports, and documents. The overload of human cognitive labor and time in finding, researching, and analyzing data is minimized.

6. Big Data: Cloud Services and the Semiconductor Industry

Maintaining a competitive edge with AI technology increasingly depends on computer chips and semiconductor resources. The buzz terms "Big Data" and "the cloud" are phrases that encompass both the memory capacity to store terabytes, and massive amounts, of data in one network infrastructure (not multiple storage networks). The keys to high-performance AI computing are semiconductors, made of silicon and germanium,

225 "Primer.Ai," accessed March 14, 2020, https://primer.ai/.

and Graphical Processing Units (GPU), for data storage and to not overload a system to the point of disruption or freezing. Although rarely found in nature, silicon can be found in silicate or oxide minerals like quartz (looks like a crystal) and is the second most-abundant element on Earth following oxygen. Germanium is a lustrous, gray-white, brittle metalloid. According to Statistia, since 2019, the top three countries that produce silicon in million metric ton are China with 4.5 million metric tons, Russia with 600 million metric tons, Norway with 370 million metric tons, and the United States in fourth with 320 million metric tons.[226] These are the two critical elements necessary to maintain a competitive advantage. AI companies have been able to build websites or platforms online and be competitive based on data quality, data quantity, and accessibility, whether the data is real or synthetic. Russia, a great power competitor, is in the running with silicon production, but this discussion goes beyond the scope of this thesis.

Synthetic data can be used for simulations. naval ISR aircraft all collecting data at sea does nothing if one's goal is to conduct FONOPS in the vicinity of the disputed islands of the South China Sea. Some AI applications use synthetic data, which are real data, or based on real historical data, and synthetic, or fake, data used for simulations.[227] A person who trains and writes machine learning algorithms is computationally intensive, but high-performance computing is necessary to maintain a competitive edge over the adversary.

Today's intelligence databases or cloud services storing Big Data are outdated, but the new Machine-Assisted Analysis Rapid-Repository System (MARS) may be a good initial adoption of cloud services. The current 20-year old intelligence database called Modernized Intelligence Database (MIDB) stores data globally for the defense intelligence organization, but with the proliferation of data and sensors, today makes MIDB insufficient and unreliable. MARS was developed for storage, cloud computing, and machine learning AI applications that will allow human operators to use a system capable of ingesting and

[226] M. Garside, "Major Countries in Silicon Production from 2014 to 2019 (in 1,000 Metric Tons)*," Statista, February 12, 2020, https://www.statista.com/statistics/268108/world-silicon-production-by-country/.

[227] AlphaGo in 2015 used historical data from human and human go matches; AlphaGo Zero in 2017 data was entirely trained with synthetic data from matches AI played against itself. Synthetic data can be viable for wargame or peace game scenarios, but is not viable for all AI applications.

managing massive amounts of data and possibly simulate courses of action quickly for operators.[228]

7. Naval Special Warfare Adopts AI for Naval ISR

NSW and SOCOM combined continue to adopt AI in innovative ways and are true early adopters. For example, on February 20, 2020, NSW contracted the company Aery Aviation, LLC ("Aery") to provide air-to-ground ISR services in Full Motion Video (FMV), specialized sensors, and communications equipment with a C-208 reconnaissance aircraft.[229] This new contract and capability encompass training and research and development exercise. The previous DOD and Google AI called Project Maven, formerly known as Algorithmic Warfare Cross-Functional Team, helps identify missiles in images or crowds through a process of "trial and error by the computer as it ingests and processes huge amounts of data."[230] While this project may have received ethical or privacy rights isuses, unmanned systems remain and innovative methodology to discriminate between the population and objectives between civilians and the military, which supports a doctrine set by the Geneva Convention (AP1).[231] AI programmed into automation systems makes it easier to conceive of patterns of hostile or combatant behavior is occurring and thus, provide both early warning and review battlespace decisions.

Special Operations Forces (SOF) are attractive units for rapid fielding and prototyping of automation and AI and re-structuring doctrine. According to American political scientist and counselor to the United States Department of State (2007-2009) Eliot Cohen, elite units can serve as laboratories or incubators for the broader force while

[228] DIA Public Affairs, "DIA's Vision of MARS: Decision Advantage for the 21st Century," DIA News, May 23, 2019, https://www.dia.mil/News/Articles/Article-View/Article/1855910/dias-vision-of-mars-decision-advantage-for-the-21st-century/.

[229] Heather McAfee, "Aery Aviation, LLC Wins Naval Special Warfare Contract," PR Newswire, February 20, 2020, https://www.prnewswire.com/news-releases/aery-aviation-llc-wins-naval-special-warfare-contract-301008746.html.

[230] Lori Robinson, "The Evolution of Artificial Intelligence and Future of National Security," *National Interest*, March 13, 2020, https://nationalinterest.org/feature/evolution-artificial-intelligence-and-future-national-security-133032.

[231] Protocol Additional to the Geneva Convention of August 12, 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol 1), June 8, 1977.

providing “fresh thinking into the mainstream of military thought”[232] and to shape a more efficient AI doctrine. In the book *Special Ops* by former Navy SEAL and former head of USSOCOM Admiral William McRaven, SOF defies conventional wisdom and via constant repitition in training and rehearsals, is the key link in achieving a simple mission in planning phase with the elements of surprise and speed in the execution phase.[233] Thus, special operations and elite units identify, utilize, and report deficiencies among each group of innovators along the S-Curve when tasked with specific problems and specific objectives.

8. Private, Public, and Commercial Way of Adopting Automation and AI

While China may produce the world’s largest amount of silicon in the world, American private and commercial custom-designed chips and GPU innovations derive from American companies in further advancing memory capacity on a computer. For example, Google’s AI chip is called Tensor Processing Unit (TPU), which can offer superior performance in AI computing over GPUs for AI software. While a company called NVIDIA designs most GPUs in the United States and manufactured by TSMC in Taiwan, acquiring semiconductor design in conjunction with custom-design chips may be the next move in Big Data and cloud computing to stay ahead of the AI game.[234]

Industry exemplifies staying ahead of the AI game in a tiered system to fit the needs of the people in teams and the development cycle before deployment. For example, in June 2019, Booz Allen Hamilton, an American management and information technology consulting firm, hosted a HACKtheMACHINE digital experience event to help the Navy solve a critical future issue, which is seeking vulnerabilities and the ability to hack a ship’s system.[235] Some examples of cyber challenges and opportunities given to academic or

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[232] Eliot A. Cohen, *Commandos and Politicians: Elite Military Units in Modern Democracies* (Cambridge, MA: Center for International Affairs, Harvard University, 1978), 31–32.

[233] William H. McRaven, *Spec Ops: Case Studies in Special Operations Warfare: Theory & Practice* (Novato, CA: Presidio Press, 1996), 14.

[234] Allen, *Understanding China’s AI Strategy*, 17–18.

[235] Fathom5 and Booz Allen Hamilton, “HACKtheMACHINE 2019,” HACKtheMACHINE, June 2019, https://www.hackthemachine.ai/.

industry teams are listed in Table 6 who were able to achieve these AI challenges with AI applications such as SharkWire; hacking only within the cyber bubble of this private event.

Table 6. Capture the Flag: Hack a Newly Developed Cyber Defense for Industrial Control Systems

Low Threat	Medium Threat	High Threat
Take Advantage of the ship's position	Spoof a waypoint that causes the auto-pilot system to change course	Simultaneously move the rudder, spoof the heading, and change GPS coordinates
Crack the ship's WEP and WPA2 Wifi Passwords	Remotely access websites for Human-Machine-Interface (HMI) virtually or send fake distress signals over VHF Radio	Create a fake catostrophic weather event over the wire to cause the ship to change course

If an individual can conduct a cyber attack, these opportunities and challenges pose serious threats to naval ISR systems and platforms demand red-teaming by any team worldwide to test naval systems, if given the opportunity or challenge in a series of events. According to Dr. John Arquilla,

> Unless there is a willingness to try innovative recruitment methods for seeking out those with the necessary talents…One creative way to proceed with recruiting would be to convince skilled IT industry techs to join up and click for their country. This need not be a typical recruitment requiring several years of active duty. Instead, the focus could be on bringing talented men and women into Reserve and Guard formations, perhaps even forming up new, purpose-built cyber units. These could be sited strategically, near IT hubs.[236]

Setting up quarterly AI challenges to find the fittest AI talent and recruit "cyber sentries" from U.S. Reserve units to protect naval networks and systems can help make great strides toward adopting automation and AI and avoid the saturation point.[237]

The decentralized top DOD organizations that adopt AI may not be as connected, posing gaps and weaknesses. Top organizations include the Defense Innovation Unit (DIU), DARPA, SOFWERX, JAIC, NavalX. DIU is a DOD organization that contracts

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[236] John Arquilla, "Uncle Spam Wants You!," *Foreign Policy*, February 5, 2013, https://foreignpolicy.com/2013/02/05/uncle-spam-wants-you/.

[237] Arquilla.

with commercial companies to solve national security problems and located in Silicon Valley.[238] DARPA invests over $2 billion in new and existing AI programs in their "AI Next" campaign with more than five decades of research and development in automation in which systems can acquire new knowledge through algorithms.[239] SOFWERX is a public-private military entity located in Tampa, Florida that combines DEFENSEWERX and the United States Special Operations Command (USSOCOM) to fuse academia, civilian companies, and other non-traditional DOD partners.[240]

Specifically, the process of measuring the adoption of AI for naval ISR or for naval automation writ large remains unclear. In February 2019, another organization called NavalX, was solely designed for the Department of the Navy as a "super connector." NavalX creates social Tech Bridges between start-ups, academia, commercial, public and private companies.[241] Another major AI center called JAIC, which is designed to harness AI, likely faces significant challenging shortfalls as an organization trying to coordinate all AI efforts. The plethora of options to adopt AI without a central strategy and design can produce gaps and missed opportunities for adopting algorithms and connecting the right people to the right organization. NavalX may consider partnering with Match.com to quickly connect human operator and systems needs in a user-friendly and rapid way to become aware of specific companies like a baseball card or swiping mechanism.

9. Neural Networks and Deep Learning: Heat Maps, Trees and, GANs

Coherent change detection algorithms for terrain mapping are "hot commodities" that use machine learning and neural network techniques to determine a pattern or

[238] "Accelerating Commercial Technology for National Security," Defense Innovation Unit, accessed March 14, 2020, https://www.diu.mil/.

[239] "AI Next Campaign," DARPA - Defense Advanced Research Projects Agency, accessed March 14, 2020, https://www.darpa.mil/work-with-us/ai-next-campaign.

[240] Michael Bottoms, "SOFWERX: A Smart Factory of Innovation Helping the Warfighter," USSOCOM - United States Special Operations Command, February 2, 2018, https://www.socom.mil/Pages/SOFWERX--A-smart-factory-of-innovation-helping-the-warfighter.aspx.

[241] Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN RDA), "Welcome to NavalX," NavalX, accessed March 14, 2020, https://www.secnav.navy.mil/agility/Pages/default.aspx.

anomalies. Raytheon has developed Intersect Sentry to detect change and generates heat maps to determine change detection, tracking, and averting adversarial activity (Figure 18).

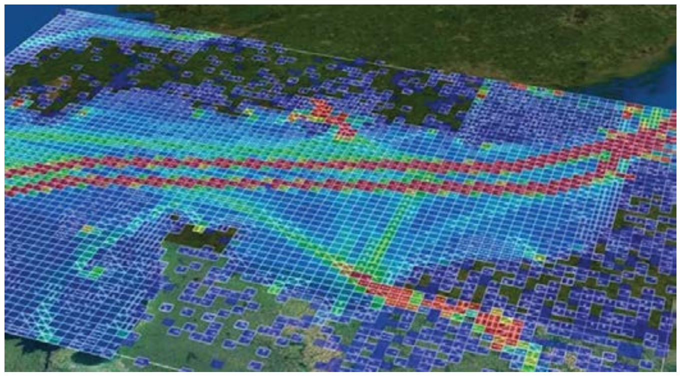

Figure 18. Algorithms in Intersect Sentry Detects and Visualizes Routes of Maritime Vessels

The significance of a heat map is that the algorithm can calculate the probability distribution to determine course, speed, and distance to determine patterns or anomalies. Heat maps help with detecting multi-dimensional anomalies and situational awareness. Some useful open-source websites with this capability include: Global Data on Events, Location and Tone (GDELT), satellite imagery, AIS data, and more.[242] To fuse all the data, the tree diagram is one useful AI technique to categorize and visualize maps.

Tree diagrams form alternative ways to determine the top two teams, instead, the algorithm creates multiple teams and categorizes them per color along the light spectrum. To create the heat map, a computer program first divides the area or target of interest into smaller parts, then the frequency of unique vessels in each part is color-coded, and lastly,

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[242] GDELT is "supported by Google Jigsaw, the GDELT Project monitors the world's broadcast, print, and web news from nearly every corner of every country in over 100 languages and identifies the people, locations, organizations, themes, sources, emotions, counts, quotes, images and events…" https://www.gdeltproject.org/.
"ADS-B improves safety and efficiency in the air and on runways, reduces costs, and lessens harmful effects on the environment," https://www.faa.gov/nextgen/programs/adsb/; "OpenStreetMap is a map of the world, created by people like you and free to use under an open license," https://www.openstreetmap.org/#map=4/38.01/-95.84; "The National Oceanic and Atmospheric Administration is an American scientific agency within the United States Department of Commerce that focuses on the conditions of the oceans, major waterways, and the atmosphere," https://www.noaa.gov/.

the density in traffic of vessels is calculated based on the number of vessels per unit area (Figure 19).[243]

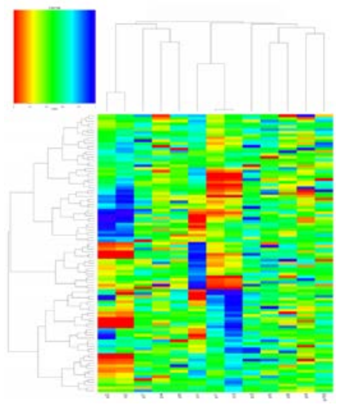

Figure 19. Heatmap and Trees Indicate Variables and Clustering of Colors[244]

A strategy for rapidly training and prototyping machine learning is to integrate Generative Adversarial Networks (GANs) into AI platforms for naval ISR. According to Ian Goodfellow, Yoshua Bengio, a researcher in machine learning and deep learning, proposed GANs, which is a new framework for estimating generative models through an adversarial process. To illustrate possible anomalies, this algorithmic technique helps detect, classify, and discriminate the input attributes. Examples of anomalies include false positive or false negative objects or vessels produced by sensors onboard ISR platforms.

China's fleet is growing and modernizing rapidly to the U.S. Navy with its strategy of late adoption and late modernization, but the U.S. Navy still deploys a larger, heavily armed, and greater military force. According to the Office of Naval Intelligence, in the last two decades, PLAN has been on track to increase its naval capability by 2020 and AI is helping its fleet reach its goals to surpass both the U.S. Navy.[245]

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[243] Christine Nezda, "Machine Learning for Patterns of Life," *Technology Today*, no. 1 (2018): 26–29.

[244] Source: Nezda, "Machine Learning for Patterns of Life."

[245] Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century* (Washington, DC: Office of Naval Intelligence, 2015), 13, https://www.oni.navy.mil/Portals/12/Intel%20agencies/China_Media/2015_PLA_NAVY_PUB_Print.pdf?ver=2015-12-02-081247-687.

V. SUMMARY AND RECOMMENDATIONS

A. INTRODUCTION

In this thesis, I have attempted to compare the different ways in which the American and Chinese navies have adopted automation and AI for naval ISR. I conceptualized how specific automation tools—Aegis, SSDS, and Type-346—improve the modern maritime battlespace. Chapter II conceptualizes the term automation—a technique, process, or system by which a machine achieves a specific goal— and AI, a more ambitious concept that posits analytic and assessment capabilities. Chapter III describes Rogers' S-Curve of technological adoption and suggests a total of five categories of adopters to standardize the usage of adopter categories. This methodology is important because, without it, matching ideas discussing and categorizing appropriate technologies to its appropriate timeline is critical in the adoption process. Chapter IV displays and analyzes ways in which both navies have adopted automation and AI naval ISR platforms and software. Although the U.S. Navy has maintained dominance in maritime superiority and air superiority, the PLAN is fast-approaching in dominating AI for future sea power.

This thesis contains a seven-step strategy and design process applicable to simple, complex, and extraordinarily complex automation or AI applications for technological adoption. This theoretical process can help identify primary demands and material necessary for successful naval ISR practices in the maritime battlespace. Human beings, the material, and physical space represent key elements. The theoretical framework in this study identified five key technological adoption capabilities: early and quarterly "campfire talks"; visionary and thought leaders; a grand strategic narrative; a design an AI development plan; lead in computer technology material resources; and, build an instantaneous and user-friendly platform for AI engineering experts and naval knowledge experts.

This chapter covers the summary of findings, the AI gap, ethics and AI, recommendations for the U.S. Navy, and future work for automation and AI tools that involve human-machine teaming for naval ISR.

B. SUMMARY OF FINDINGS

Frank Barnaby reminds us that "military technology is automating warfare."[246] Current trends show undoubtedly automated processing, fusion, and product delivery for command and control the maritime battlespace.[247] I began this investigation into automation and AI as applied to naval ISR to better understand the adoption mechanisms and categories used by both navies that not only make each navy a great competitor but also what characteristics and technologies make their forces successful naval AI powers.

The findings from the S-Curve of technological adoption for naval ISR could be important if a commander becomes inundated with information or intelligence and can, instead, stimulate a new culture to adopt a hybrid way of adopting automation and AI that folds in early adopters with later adopters. According to former CEO of Google Eric Schmidt, "The DOD has an innovation adoption problem" and should adopt a DevOps, or Development Ops, culture for software systems and focused on "customer adoption."[248] Cultural development centers on the user or tactical operators and AI engineers that serve in both navies. For example, the PLAN has a development culture of adopting technologies later. Later adopters or laggards can benefit from early innovators' successes and failures because this category of adopters focuses on adopting and "copy-catting" successful technologies and has observed what technological failures not to adopt.

Figure 20 demonstrates that both navies as near-peer competitors and are successful at adopting automation; however, they are on opposite ends of the curve. This means that

[246] Barnaby, *The Automated Battlefield*, 21.

[247] See U.S. Navy Information Dominance Corps, *U.S. Navy Information Dominance Roadmap 2013–2028* (Washington, DC: Department of the Navy, 2013), 33, https://defenseinnovationmarketplace.dtic.mil/wp-content/uploads/2018/02/Information_Dominance_Roadmap_March_2013.pdf "Assured C2 is ultimately about ensuring a commander's ability to command assigned forces to achieve the tactical, operational or strategic objectives established by the chain of command. Navy's future information infrastructure must be able to maintain essential network and data link services across secured segments of the EM spectrum in high-threat scenarios to transport, share, store, protect and disseminate critical data and combat information required by forward deployed units and on-scene commanders."

[248] Eric Schmidt, "Promoting DOD's Culture of Innovation: Testimony before the Committee on Armed Services" (2018), https://armedservices.house.gov/2018/4/promoting-dod-s-culture-of-innovation.

the U.S. Navy represents innovation and early adoption, and PLAN represents later majority and laggards of adopting technologies for naval ISR missions.

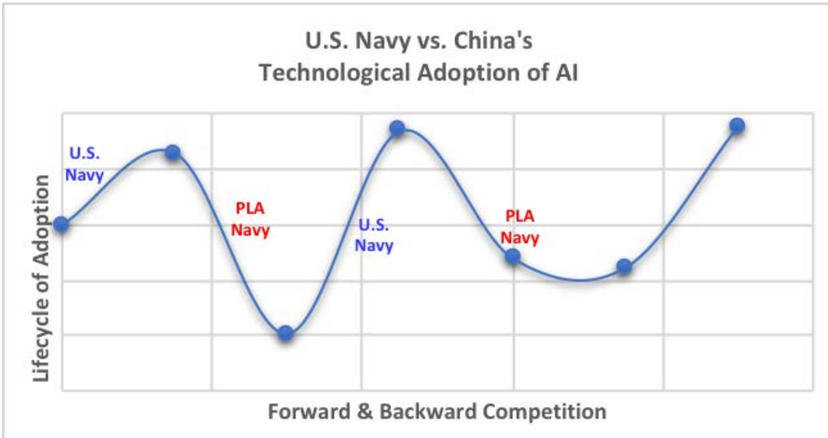

Figure 20. U.S. Navy Innovators and Adopters Compared to PLAN Later Adopters Along the Logistic S-Curve

Both great power competitors appear to co-exist and complete the wavelength within a forward or backward thinking way of adopting technologies, but the political system can impact the rate of adoption whether it is by an innovator or later adopter.

1. AI Benefits an Autocratic Navy

The rate at which automation and AI technologies are adopted tends to benefit an autocratic society. According to CCP's AI strategy, China's plan is to become the global innovation center by rapidly developing AI, reinforcing China's lead in adopting automation for naval ISR.[249] China's population is over 1.4 billion citizens, with approximately 290,000 PLAN personnel, which roughly equates to 12.6 percent of PLA's 2.3 million personnel. Since 2018, China has led the world in publishing approximately 42.64 percent of top AI papers, approximately 52 percent of AI global patents, and places second in AI companies with over 1,011 companies compared to the 2,028 of U.S. AI

[249] Sapio, Chen, and Lo, *A New Generation of Artificial Intelligence Development Plan*.

companies.[250] The authoritarian system creates an environment that values security over privacy for China's massive population because the government and AI companies are ultimately controlled by the Chinese Communist Party. In the private sector, China leverages Baidu, Alibaba, and Tencent (collectively referred to as BAT) for fueling the growth of AI with fewer privacy restrictions compared to the West. China has the advantage of a higher population in an open society to assist with cleaning data, to develop or copy algorithms, and to collect and surveil naval platforms at sea with open-source data and social media. Perhaps, the powerful feedback loop between corporations developing AI and the CCP is a marriage made in heaven for PLAN; alternatively, this is a match made in hell for the U.S. Navy.[251]

2. Automation and AI: Changes in International Maritime Governance

PLAN has since been able to take advantage of and lay claim to a new model of maritime governance and is rapidly approaching its dominance in AI. China has already begun to overtake the U.S. Navy in adopting automation. In China's Tsinghua University's recent work on AI development, stage five (2017 to present) of China's national AI policy evolution shows the characteristics of next-generation AI among the military, industry, and the civilian sector.[252] Since 2013, PLAN and China built and militarized its self-made islands (i.e. Fiery Cross, Subi Reef, Mischief Reef) in SCS with cruise missiles and air

[250] China Institute for Science and Technology Policy, *China AI Development Report 2018*, 3–4.

[251] The ease of crosspollination between the People's Liberation Army (PLA) and its private, public, and commercial center can help build compatible hardware and software faster. Other cost-effective, structure IT architecture (i.e. Wide Area Network connections with Cloud Services), social media, and more.

[252] Since the time of release of key AI policy documents, China's AI policies divided into five stages: "Stage 1 (before 2013), of potential development, where few policy documents were released and AI was not specified as a national priority; Stage 2 (2013-2015), of preliminary development, where the importance of AI began gaining recognition across all circles of society; Stage 3 (2015-2016), of rapid development, where a lot of policies documents were released and AI was elevated as a national strategy; Stage 4 (2016-2017), of stable development, where understanding of AI R&D and industry development was increasingly mature and policy documents came out stably; and Stage 5 (2017 to the present), of steady iteration, where all sectors have a more pragmatic understanding of AI and related policies are more specifically targeted."

defense systems.[253] Within the first island chain, the PLAN has the "home-court" advantage to surveil and maintain its 12-nautical-mile zone around the disputed islands in the SCS. PLAN continues to use *Dongdiao*-class AGI spy ships to learn about U.S. naval affairs. As later adopters, the PLAN will likely be able to "copy-cat" successful naval ISR tactics and operations demonstrated by the U.S. Navy.

The PLAN is taking the lead in AI over the U.S. Navy with its spy ships, reconnaissance satellites, and OTH radars by collecting massive amounts of data. Moore's Law, where the number of transistors per silicon chip—computing processing—power doubles every two years, leads to rapid growth and productivity.[254] The PLAN is taking advantage of collecting massive data from sea to space assets to produce high quality data. If computer processing doubles every two years, it will be less challenging to filter through with high-quality data collected over time and easier to locate in a central data storage (i.e., the cloud).

As the PLAN continues to build more network infrastructure locally and globally, it shows its willingness to take short-term risks for long-term advantages. Another long-accepted factor, Metcalfe's Law, asserts that the value growth of the fully connected network is proportional to the square of the number of compatibly communicating devices.[255] For example, if a network has five nodes fully interconnected with each other, the inherent value of each being x, its power is 100x (due to its ten distinct links) versus the 5x power of a single-linked network. While the value of the networks increases for compatible communication, it also increases cybersecurity issues if a competitor disrupts or hacks one of those nodes. The PLAN's is willing to take the risk of computer network attacks to dominate in AI for long-term strategy.

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[253] David Axe, "How China Is Militarizing the South China Sea with a Ton of Missiles," *National Interest*, March 23, 2020, https://nationalinterest.org/blog/buzz/how-china-militarizing-south-china-sea-ton-missiles-136297.

[254] "Moore's Law," in *Encyclopaedia Britannica*, July 21, 2011, https://www.britannica.com/technology/Moores-law.

[255] "Metcalfe's Law," in *Cambridge Dictionary*, accessed April 2, 2020, https://dictionary.cambridge.org/us/dictionary/english/metcalfe-s-law.

3. U.S. Navy's First Mover Advantage: Semiconductors and Software

However, the U.S. leadership in AI already extends beyond the U.S. littorals, has more naval personnel than the PLAN, and leads material resources necessary to build network infrastructures. While the U.S. population is 329.4 million,[256] lower than China's overall population, the U.S. Navy has 339,448 personnel, which is more than the number of personnel in the PLAN.[257] The U.S. Navy has the first-mover advantage to adopt AI technologies not simply because it has more people than the PLAN, but because the United States leads in top AI companies. Specifically, U.S. AI companies focus on enterprise software, semiconductors, and quantum computing.

However, the marriage between the U.S. Navy and industry or private companies can present significant issues and friction with AI engineers who do not or do not consistently support the military with AI. Great American talent derives from Silicon Valley, the Joint AI Center, DOD's programs such as DARPA, DIU, and NavalX. However, the top AI companies such as Google, Facebook, and Amazon have received criticism for privacy rights issues and public opinion of the weaponization of AI creates issues of seamless collaboration. Even though the U.S. Navy and the DOD appear to lead in some aspects of AI when collaborating with Silicon Valley to prototype and field commercial AI tools within 60 to 90 days,[258] this does not apply to all naval ISR platforms. USSOCOM may be able to take advantage of commercial AI tools with Silicon Valley-based AI engineers, but conventional U.S. Navy may likely years or decades to fully automate and adopt AI tools with legacy, conventional platforms.

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256 "U.S. and World Population Clock," United States Census Bureau, April 3, 2020, https://www.census.gov/popclock/.

257 "Status of the Navy," U.S. Navy, April 3, 2020, https://www.navy.mil/navydata/nav_legacy.asp?id=146.

258 "Defense Innovation Unit: Who We Are/Our Mission," Defense Innovation Unit, accessed April 22, 2020, https://www.diu.mil/about.

4. An Automated Aircraft Carrier May Be Powerless in Future of AI and Sea Power

ISR technologies make it nearly impossible to hide naval platforms, and massive amounts of data can deceive the competitor. In his article, "Artificial Intelligence on the Battlefield," Dr. Zachary Davis, a Senior Fellow at Lawrence Livermore National Laboratory and Professor at the Naval Postgraduate School, believes, "AI could erode stability by increasing the perceived risk of a surprise attack," and AI-supported ISR platforms on one side can confuse other exquisite ISR.[259] With many naval ISR operators working long hours and unable to fully vet the relevancy and accuracy of locating mobile targets, and also strike with speed and precision, Davis claims ISR operators today are easily victimized by the massive amounts of data and the over-collection of data with which the competitor is all too eager to manipulate or deceive the other competitor.

C. THE AI GAP: MISSING AI PLATFORM TO CONNECT AI ENGINEERS AND OPERATORS/USERS

This study reveals that there is no apparent central automation or AI tool with instantaneous notification techniques connecting the AI engineer to the knowledge expert or naval user to fix issues faster.[260] Bridging the gap automatically can significantly help gain customer and competitor insights. According to a RAND study on assessing data analytics, a particular challenge is associated with the collection and use of unstructured data, and not in fixed locations such as a relational database.[261] Automating an AI platform for AI engineers and naval users directly and within one central database is vital for the U.S. Navy to resolve and master. Adopting a new platform to connect AI builders and naval users will help surpass the inflection point of technological adoption.

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[259] Zachary S. Davis, *Artificial Intelligence on the Battlefield: An Initial Survey of Potential Implications for Deterrence Stability and Strategic Surprise* (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2019), 14–16, https://cgsr.llnl.gov/content/assets/docs/CGSR-AI_BattlefieldWEB.pdf.

[260] Refer to Chapter 1, pages 6–7 regarding Stanford University Professor Feigenbaum's "Expert System."

[261] Philip S. Anton et al., *Assessing the Use of Data Analytics in Department of Defense Acquisition* (Santa Monica, CA: RAND Corporation, 2019), https://www.rand.org/pubs/research_briefs/RB10085.html.

Despite the increased collection of information, this study reveals that descriptive and diagnostic styles, specifically visual analytics and trend analysis, are utilized. AI provides information about what has happened in naval ISR (i.e., platforms and sensors) and diagnostic AI pinpoints the exact problem or issues quickly. As mentioned in Chapter IV, the U.S. Navy adopted an OTH visual analytical tool for early warning of incoming naval platforms. Descriptive Both descriptive and diagnostic styles of AI are fundamental processes to master prior to adopting more complex predictive and prescriptive AI, typified by neural networks, pattern recognition, machine learning, and deep learning.

Predictive AI is lacking in the U.S. Navy's arsenal of data analytics. Predictive AI provides data as to what will likely happen—where a naval platform may go next or possibly why it is going to specific locations next. Examples of predictive AI techniques are machine learning, pattern recognition, and statistical modeling; this approach to AI programming uses historic and statistical data to conduct trend analysis of naval activities. Predictive and prescriptive AI are advanced techniques necessary to maintain a competitive posture toward China.

Prescriptive AI is also lacking. Prescriptive AI provides data on what will happen and what could happen better if naval ISR platforms conduct x, y, or z maneuvers at sea, based on historic data, and provide recommendations. Examples of prescriptive AI include supervised learning algorithms such as "random forest," which creates and merges decision trees into one "forest" based on previously collected data or models. This can help support future heat mapping and Generative Adversarial Networks (GANs) techniques for war-gaming or "red-teaming" against competitors like the PLAN. Simply put, whether the navies adopt early or after all other navies have adopted specific automation or AI technologies, perfecting the basics and developing a culture of innovation and AI operations at each level of command remains critical to the success of leading in AI.

Another AI platform the U.S. Navy lacks is one that distinguishes possible abnormalities or anomalies from "normal" patterns of life at sea.[262] To develop and adopt technologies to distinguish abnormalities or anomalies at sea, the currently available material, such as semiconductors and software talent from Silicon Valley, should be accessed and tested consistently and frequently. Issues of software or hardware deficiency can lead to latency in updating, which may ultimately pose issues in identifying and locating PLAN forces operating at sea.

The commercialization of AI and military technologies can be the next game-changing threat.[263] Drones sold and used by the commercial industry can lead to the competitor using swarm tactics against critical sensors such as Aegis, SSDS, or Dragon Eye radars. Each level of automation and AI adds a layer of complexity to diagnose, predict, and prescribe the next move by the PLAN. Moreover, if PLAN develops AI with the commercial sector, it creates less control by the U.S. Navy over the specific software or hardware updates. Less control over specific automation or AI tools can lead to other competitors or adversaries buying, selling, and adopting the tools and using them directly against the U.S. Navy.

D. RECOMMENDATIONS

This study provides four major recommendations. First, the U.S. Navy should develop a popular platform for direct feedback and change the culture to streamline the connection between AI engineers and tactical operators, like Amazon's instant feedback loop. Another exemplary community that is already adopting emerging technologies quickly is the Special Operations Force (SOF), specifically Special Operations Command

[262] Pattern of life software exists to analyze large amounts of data from many different sensors represented on a Common Operational Picture or large graphs to find distinct behavior patterns that may indicate a deviation from normal modes of operation, malintent, or anomalous patterns. Any deviation from expected pattern sends immediate "red flags" that can tremendously help understand the competitors normal or abnormal behavior, help prevent collisions, and proactively prepare appropriate and professional responses

[263] Zachary Davis, Michael Nacht, and Ronald Lehman, eds., *Strategic Latency and World Power: How Technology Is Changing Our Concepts of Security* (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2014), 11, https://cgsr.llnl.gov/content/assets/docs/Strategic_Latency.pdf.

(USSOCOM). DOD organizations such as DIU, NavalX, and USSOCOM can give, according to NPS Professor Leo Blanken, “a simple and cost-effective way to improve existing innovation efforts in the field: aligning military graduate researchers with deployed special operations units to rapidly prototype. concepts and technologies.”[264] The SOF community provides an attractive testbed for rapid prototyping and instantly connect tactical users to AI engineers.

Second, the U.S. Navy should invest in and adopt a “DevOps” culture to maintain a competitive advantage over the PLAN. In a hierarchical organization, cultivating and practicing DevOps will inherently start with an AI school or time for education in the pre- and post-deployment cycle. This can only be indoctrinated and inspired by senior officers in charge. Arguably, the U.S. continues to lead in innovation and software technology and talent but can further improve by co-locating U.S. naval commands or headquarters nearby commercial and private AI companies to cultivate and adopt the next AI breakthrough.

Third, while implanting more automation and AI into the aircraft carrier, the corresponding doctrine should consider swarm tactics and cyberspace. Just like hives of bees can swarm a bear and overtake him, the autonomous drones can easily swarm a carrier strike group, particularly *Aegis* or SSDS and its associated antennas.[265] The consequence of not incorporating swarm technologies with operational and tactical ISR missions can lead to the competitor destroying Aegis or Type-346 with very little cost and tremendous damage to naval ISR.

Fourth, both navies share cyberspace. JP 3-12 defines information dominance as “the degree of dominance in cyberspace by one force that permits the secure, reliable conduct of operations by that force, and its related land, air, maritime, and space forces at a given time and place without prohibitive interference by an adversary.”[266] Cyberspace

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[264] Leo Blanken, Philip Swintek, and Justin Davis, “Special Operations as an Innovation Laboratory,” War on the Rocks, February 25, 2020, https://warontherocks.com/2020/02/special-operations-as-an-innovation-laboratory/.

[265] John Arquilla, *In Athena’s Camp: Preparing for Conflict in the Information Age* (Santa Monica, CA: RAND Corporation, 1997), 465.

[266] Joint Chiefs of Staff, *Cyberspace Operations*, Joint Pub 3–12 (Washington, DC: Joint Chiefs of Staff, 2018), GL-4, https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_12.pdf.

is the Achilles heel of automated naval platforms because automation and communication between naval ISR platforms rely on sharing the information space and deconflicting frequencies to communicate.

In this thesis, I discovered five points that should be considered when adopting automation and AI for naval ISR:

1. Develop a strategic narrative from day one and discuss the AI strategy at each level of command. A strategic narrative is a special kind of story that an organization can clearly understand and engage with the story. This is important because it tells other maritime competitors who you are, where you have been, where you are going, and where you are. Each command should want to inspire its military service members, excite allies and partners, and attract users such as the AI engineer(s) and human operators.

2. The country and navy that has control of the technological materials necessary to build automation and AI, such as semiconductors, silicon, and germanium, will dominate in AI in future sea power. Is the market ready to support the military's solutions in naval ISR?

3. Success or failure of adoption of automation relies significantly, if not entirely, on the control of the electromagnetic spectrum and ability to deconflict frequencies.

4. There should be an automated AI feedback platform so that military users and AI engineers can text and speak directly. A winning and better end-to-end product requires great user experience for efficient workflow and instantaneous reporting.

5. The significant insight between early adopters and laggards shows that the U.S. Navy and PLAN are on opposite ends of the wavelength of technological adoption and competition. In Rogers' work on the S-Curve of technological adoption in Chapter III, both American and Chinese naval leaders falling on opposite ends of the S-Curve suits each of their organizational and doctrinal structures.

E. THE FUTURE OF SEA POWER AND FUTURE WORK: HUMAN-MACHINE TEAMING

Humans and machines teaming together is the key to the adoption of automation and AI in naval ISR affairs. This section covers future work and long-term considerations in the adoption process of automation and AI. These factors are: automate health indicators for the operator; take advantage of research in quantum computing; and, the increase of various reality technologies (virtual, augmented, and mixed).

1. Team AI Health: COVID-19

The center of gravity for Naval ISR and adopting automation or emerging technologies depends on healthy human operators on naval platforms to operate the systems. If an epidemic disease spreads throughout one aircraft carrier such as *USS Theodore Roosevelt* (CVN 71), then all ISR in support of carrier operations halts and the U.S. Navy fails to adopt AI for surveillance—with consequences that could lead to life or death situations.[267] AI can provide significant human-assisted tools that can automate clear indicators.

Commanders will find it useful to strategize various designs and design a strategy to integrate health practices and AI for naval operators. An automated stop-light chart and daily tracker with notification symbols that blink, or flash will help indicate a diagnosed problem or trigger for commanders and decision-makers. A simple model to automate indicators related to biological event-related social disruption is the Wilson-Collman Scale of four stages of the increased likelihood of a biological event: favorable conditions, unifocal or multifocal biological events, severe infrastructure constraint, and depletion of local response capacity, and then social collapse.[268] A second complex model is Johns

[267] Lucy Craymer, "Virus Grounds a U.S. Aircraft Carrier as Crew Quarantined in Guam," *Wall Street Journal*, April 1, 2020, https://www.wsj.com/articles/virus-grounds-a-u-s-aircraft-carrier-as-crew-quarantined-in-guam-11585736476.

[268] See James M. Wilson et al., "A Heuristic Indication and Warning Staging Model for Detection and Assessment of Biological Events," *Journal of the American Medical Informatics Association* 15, no. 2 (April 2008): 158–71, https://doi.org/10.1197/jamia.M2558 can be used to "determine the level of concern warranted, such as whether the pathogen in question is responding to established public health disease control measures, including the use of antimicrobials or vaccines; whether the public health and medical infrastructure of the country involved is adequate to mount the necessary response." .

Hopkins Coronavirus interactive map.[269] Another database to extract or utilize models from is Cornell University's arXiv database for top AI researchers in the world submitting to Stanford University's prominent repository (see the appendix).[270] Automating lists of SWOT in an interactive way can benefit naval ISR. This is important because having a clear defined list of tasks and problems helps diagnose problems as early as possible and finding the right AI researchers quickly.

2. Quantum Computing

Further research into quantum computing will contribute to the U.S. Navy's successful adoption of AI. Quantum computing goes beyond binary digits (bit value of either 0 or 1), which is the smallest unit of data in a computer, and uses what researcher Thomas Campbell calls "qubits, in which an individual bit can be in one of three states: on, off, and, uniquely, both on and off simultaneously."[271] In the U.S. National Quantum Initiative of 2018, Congress identified the National Institute of Standards and Technology (NIST) and the Department of Energy's Quantum Information Science Research Centers as top leading departments for quantum computing. Thus, the U.S. Navy should continuously collaborate with NIST and DOE closely.[272] In this case, Congress is one of the top keys in financing and putting forth bills to initiate the adoption of emerging technologies within the Navy. While in its infant stages, quantum computing can increase AI speed, particularly in machine learning, in order to spot patterns rapidly and filter through massive datasets; it will cast the long shadows of future sea power.

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269 See Johns Hopkins University, "COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)," Johns Hopkins Coronavirus Resource Center, accessed May 26, 2020, https://coronavirus.jhu.edu/map.html.

270 arXiv, "Artificial Intelligence," accessed September 11, 2019, https://arxiv.org/list/cs.AI/recent.

271 Thomas A. Campbell, *Artificial Intelligence: An Overview of State Initiatives* (Evergreen, CO: FutureGrasp, LLC, 2019), 11, http://www.unicri.it/in_focus/files/Report_AI-An_Overview_of_State_Initiatives_FutureGrasp_7-23-19.pdf.

272 National Quantum Initiative Act, Pub. L. No. 115–368, 132 Stat. 5092 (2018), https://www.congress.gov/bill/115th-congress/house-bill/6227.

3. Ethics and AI

The United States and China have both released "principles" rather than focusing on the controversial issue of whether automation and AI are ethical, morally permissible, or not morally permissible. In June 2019, China's Ministry of Science and Technology published the "Governance Principles for a New Generation of Artificial Intelligence: Develop Responsible Artificial Intelligence," which lists eight principles of AI governance: (1) harmony and friendliness; (2) fairness and justice; (3) inclusiveness and sharing; (4) respect for privacy; (5) security and controllability; (6) shared responsibility; (7) open cooperation; (8) agile governance. In February 2020, the DOD's Defense Innovation Unit spent 15 months prior to announcing its adoption of five principles of AI ethics: They should be Responsible, Reliable, Equitable, Governable, Traceable.[273] Releasing principles like the ethical AI guidance suggests that both nations desire flexibility, but also responsibility in the development of AI. With or without principles, major controversies over the use of AI quickly become relevant to issues on AI misidentification and the possibility of weaponizing automation and AI tools.

First, ethical issues exist related to AI and the military that have been portrayed both in the movies, such as *Terminator* or *I, Robot*, which began as thoughtful short stories by Isaac Asimov,[274] and demonstrated in real-life situations. Some argue that military technology or the use of AI in the military should not continue, due to the possibility that computer systems could act on their own accord or make their own lethal decision based on popular movies and social media. If AI tells a human operator that an aircraft is hostile, only seconds exist for the Commander to decide to respond or not respond based on the information available. However, since 1988, the adoption of automation and AI engineered in ISR platforms has increased transparency and avoided incidents like *USS Vincennes*,

[273] C. Todd Lopez, "DOD Adopts 5 Principles of Artificial Intelligence Ethics," DOD News, February 25, 2020, https://www.defense.gov/Explore/News/Article/Article/2094085/dod-adopts-5-principles-of-artificial-intelligence-ethics/.

[274] Isaac Asimov, *I, Robot* (New York: Bantam Books, 1950).

which was a human error and not a machine error.[275] Arguably, automation helps for defense against friendly or enemy fires and for national security.

Second, in human-machine teaming, humans are moral agents and machines are not, but can be built to provide ethical choices. In Aristotle's *Nicomachean Ethics*, a virtuous person does not hold an openly virtuous attitude but, rather, is one who acts in certain ways in specific situations, with a range of reasons. Humans can consciously make separate choices; whereas machines today simply assist human beings in making decisions. In the U.S. Navy, ethical matters likely depend on a traditionalist or legalist perspective, or possibly a revisionist view of an idea with a more inquisitive or possibly utilitarian mindset.[276]

In the PLAN, future work on ethics and the adoption of automation can be studied through the ethical decisions made by the PRC and CCP. In China, ethics relate closely to virtue ethics, concerning how one ought to live, and consequentialism, concerning the benefit of all involving material goods.[277]

While AI machines today are autonomous to a certain extent, AI machines could eventually present consequences based on specified moral ethical codes quicker than a human can think about them. Two serious ethical issues are: can autonomous systems be, or will they be categorized as moral agents in the future? What happens when there is a lack of accountability regarding amoral agents—autonomous systems—that violate human laws of war in life or death situations?[278] These ethical questions posed by NPS Professor Bradley Strawser are worth considering, but go beyond the scope of this thesis.

[275] Dirk Jan Barreveld, ed., *Air Crash Investigations: Killing 290 Civilians - The Downing of Iran Air Flight 655 By the USS Vincennes Kindle Edition* (Morrisville, NC: Lulu Enterprises, Inc., 2016).

[276] Seth Lazar, "War," in *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta (Stanford, CA: Metaphysics Research Lab, Stanford University, 2020), https://plato.stanford.edu/entries/war/.

[277] David Wong, "Chinese Ethics," in *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta (Stanford, CA: Metaphysics Research Lab, Stanford University, 2018), https://plato.stanford.edu/entries/ethics-chinese/.

[278] Bradley J. Strawser and David Whetham, *Killing by Remote Control: The Ethics of an Unmanned Military* (Oxford, UK: Oxford University Press, 2013), 16–17.

4. Human-Machine Teaming and Virtual Reality (Augmented Reality)

While I share great enthusiasm for automation and AI's potential to greatly improve human wellbeing, the development of machines with intelligence superior to humans could cause cognitive dissonance within the mind of a human operator and possibly be used as a deterrent mechanism.[279] Albert Einstein warned the power of the atom could change our modes of thinking. The atomic bomb led to the nuclear catastrophes of Hiroshima and Nagasaki. Then nuclear power turned into the idea of a "nuclear Armageddon," which is a theoretical scenario involving the use of nuclear weapons to cause widespread destruction and eventually, the collapse of civilization. Today, former Secretary of State Henry Kissinger, among many others, believes AI threatens our consciousness and our way of understanding truth and reality.[280] The notion that AI can be used as a deterrence tool is an important question that can be further studied in future research.

Based on this study, the more automated the naval ISR platforms and the increase of AI tools, the more virtual naval affairs and sea power will become. Recent reports like the U.S. "Extended Reality Applications in U.S. Defense Training, 2020" shed light on the daily impact of digital transformation on human beings and has extended to Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technologies that could be the next disruptive technologies. The commercialization of various forms of VR may become a threat against naval forces.[281] This study has not addressed reality technologies, VR, AR, or MR can be extremely useful to keep human beings safe from harm or as a deterrence tool.

With Einstein's and Kissinger's warnings on the catastrophe of a nuclear war and AI threatening our human consciousness, respectively, AI could possibly trend toward a

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[279] For instances, person's reality may come into question when operating at sea if the automation system tells the human operator a ship or submarine is operating in one location, when in fact it could be an autonomous beacon replicating the same characteristics as a naval platform.

[280] Graham Allison, "Is China Beating America to AI Supremacy?," *National Interest*, December 22, 2019, https://nationalinterest.org/feature/china-beating-america-ai-supremacy-106861.

[281] Frost & Sullivan, *Extended Reality Applications in U.S. Defense Training, 2020* (San Antonio, TX: Frost & Sullivan, 2020), https://www.researchandmarkets.com/reports/5007728/extended-reality-applications-in-us-defense.

“cognition war.” A cognition war would be the use of automation and AI on the maritime battlefield, virtually controlled by human beings not physically at sea. As a deterrence tool, AI can be used to threaten the competitor with the possible existence of naval threats at sea with “fake injected data” when in reality, no machine is present or has been present.

Humanity is at the edge of information dominance in a revolution driven by automation and AI. From ancient times, fleets at sea have sought to know what lay beyond the horizon, where the enemy might lurk. A century ago, the rise of radio and radar mounted on piloted aircraft gave navies the ability to extend surveillance far beyond horizons. Ironically, the ultimate effect of AI solving problems and managing information may be the transformation of human reasoning, intelligence, and decision making. Today, automation is both extending its reach globally and interpreting the flood of information to solve problems and create full transparency more than ever before. Truly, automated ISR is changing human knowledge, perception, reality, and, ultimately, the face of 21st Century sea power.

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APPENDIX

A. USING AI TOOLS TO FIND AI TALENT

The acceleration for research and development of Artificial Intelligence (AI) has globalized social networks worldwide. AI social networks thrive in research facilities from superpower countries like the United States and China can cross-pollinate for research to advance research in AI software. Top popular AI emerging technologies topics are Machine Learning (ML), Computer Vision (CV) and Pattern Recognition (PR). ML enables machines to learn from a task from a previous experience without new programming by a human; CV uses AI to detect and identify images; and, PR combines the two in which a computer recognizes patterns based on ML and CV results.[282] The researchers writing AI papers at academic research facilities can be recruited for their skills.

The data is from a repository arena within Cornell University's arXiv database of research submissions worldwide. The purpose is to provide a potential network analysis of how AI can be adopted and researched in academia (in terms of computer vision, machine learning, pattern recognition, etc.), by who and paper topics. This network is a two-mode data set (author to paper).

The ML, CV, and PR data used in this researched is derived from Cornell University's arXiv website. Cornell's arXiv is a central database and electronic repository for approved scientific papers with over 10,000 submissions per month and not fully peer reviewed. research, recognition, and possible funding for future work.[283] The benefit of such a worldwide, open-source website with AI authors and AI papers is access to trending or innovative research. A second benefit is to be able to disrupt their network and directly recruit individuals or a pool of people talented and driven in AI research. Relational ties and organizations included in this network will encompass the approved papers submitted

[282] "8 Best Topics for Research and Thesis in Artificial Intelligence," GeeksforGeeks: A Computer Science Portal for Geeks, accessed February 20, 2020, https://www.geeksforgeeks.org/8-best-topics-for-research-and-thesis-in-artificial-intelligence/.

[283] "Artificial Intelligence."

within arXiv database from 2009 to 2019 (Figure 21). The dataset will be bounded by the following topics: AI bulk, computer vision and pattern recognition, statistical machine learning, and database.

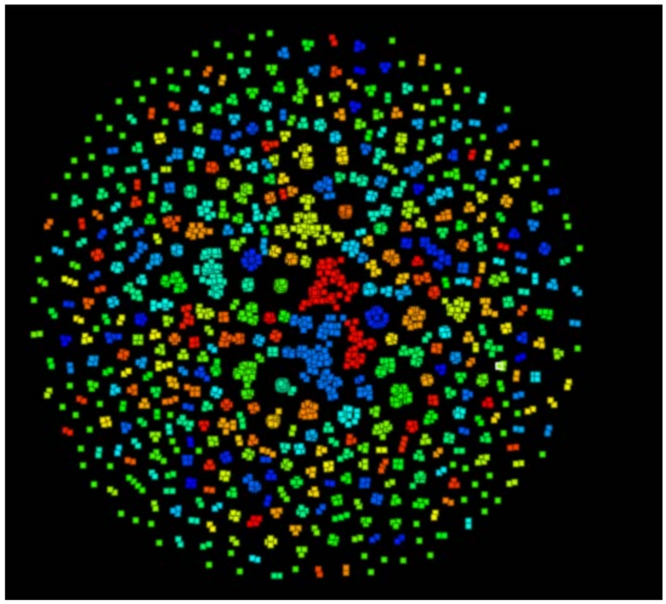

Figure 21. Cornell University's ArXiv Researchers: Computer Vision and Pattern Recognition: Paper to Person 1,999 Nodes, Density, Clustering Coefficient

Figure 22 represents the group size statistics on the number of groups, isolated groups, two per group (dyad), three per group (triad), and larger groups of researchers working together. The algorithm in a computer software called ORA, an analytical tool used for social network analysis, automatically generates visual representations of interconnected nodes from a specific dataset input into the software, which in this case was derived from arXiv.[284]

[284] "ORA," Center for Computational Analysis of Social and Organizational Systems (CASOS), accessed November 11, 2019, http://www.casos.cs.cmu.edu/index.php.

Group Size Statistics	
Number of groups	1,220
Number of isolate groups	677
Number of dyad groups	66
Number of triad groups	140
Largest group	158
Larger Group Statistics	
Number of larger groups	337
Minimum size	4
Maximum size	158
Average size	8
Std.dev size	13

Figure 22. Computer Vision and Pattern Recognition: Density, Clustering Coefficient

The aggregated sociography for CV and is moderately connected network. The metrics shows a total of 1,220 groups with 5.4 percent dyad and 11.5 percent triad co-authorship and 55 percent single authorship, which indicates the majority work independently on papers. Figure 23 displays the top 10 actors in the network within 10 diverse types of groups and his or her value through the Girvan-Newman algorithm.

K-Core	Number of nodes	Percent of nodes
0	3998	100%
1	3321	83.07%
2	2919	73.01%
3	2123	53.10%
4	1189	29.74%
5	577	14.43%
6	300	7.50%
7	156	3.90%
8	125	3.13%
9	101	2.53%
10	91	2.28%
12	80	2.00%
14	54	1.35%
15	39	0.98%
18	38	0.95%

Rank	Group-1	value	Group-2	value	Group-3	value	Group-4	value	Group-5	Group-6	value	Group-7	value	Group-8	value	Group-9	value	Group-10	value
1	Guillermo Sapiro	62	Yi Ma	48	Mita Nasipuri	94	Chunhua Shen	75	Jan Egger	Dakshina Ranjan Kisku	32	M. Emre Celebi	42	Jeffrey Mark Siskind	42	Rocio Gonzalez-Diaz	18	N. V. Kalyankar	28
2	Michael M. Bronstein	46	Lei Zhang	39	Debotosh Bhattacharjee	76	Anton van den Hengel	44	Bernd Freisleben	Phalguni Gupta	31	Hitoshi Iyatomi	23	Andrei Barbu	40	Cristian Sminchisescu	17	Firouz Abdullah Al-Wassai	18
3	Yann LeCun	35	Shuicheng Yan	36	Dipak Kumar Basu	60	Jian Zhang	21	Christopher Nimsky	Jamuna Kanta Sing	19	William V. Stoecker	22	Siddharth Narayanaswamy	38	Adrian Ion	12	Salem Saleh Al-amri	11
4	Jonathan Masci	27	Allen Y. Yang	35	Subhadip Basu	58	Lei Wang	20	Miriam H. A. Bauer	Massimo Tistarelli	16	Gerald Schaefer	14	Aaron Michaux	36	Belen Medrano	9	Ali A. Al-Zaky	8
5	Laurent Najman	26	David Zhang	23	Mahantapas Kundu	53	Peng Wang	20	Daniela Kuhnt	Hunny Mehrotra	15	Hassan A. Kingravi	13	Alexander Bridge	36	Maria Jose Jimenez	8	Ali A. Al-Zuky	6
6	Mariano Tepper	25	Arvind Ganesh	19	Nibaran Das	28	Qinfeng Shi	18	Ron Kikinis	Banshidhar Majhi	10	Randy H. Moss	13	Dan Coroian	36	Pedro Real	8	S. D. Khamitkar	5
7	Alexander M. Bronstein	23	Zhouchen Lin	18	M. Kundu	28	Anthony Dick	18	Andreas Kolb	Ajita Rattani	10	Harold S. Rabinovitz	13	Sven Dickinson	36	Mabel Iglesias-Ham	7	Khamitkar S. D	5
8	Jürgen Schmidhuber	21	S. Shankar Sastry	17	D. K. Basu	25	Xi Li	17	Barbara Carl	V. Bhawani Radhika	9	Giuseppe Argenziano	13	Sam Mussman	36	Walter G. Kropatsch	7	Khamitkar S. D.	5
9	Ron Kimmel	18	Ju Sun	17	Ayatullah Faruk Mollah	23	Yixiong Liang	15	Sebastiano Barbieri	Enrico Grosso	7	H. Peter Soyer	13	Dhaval Salvi	36	Marius Leordeanu	6	1002.1148v1	3
10	Arthur Szlam	17	Wei Zhang	16	Sandip Rakshit	23	Beiji Zou	15	Jan Klein	Manuele Bicego	7	Joseph M. Malters	11	Lara Schmidt	36	Rahul Sukthankar	6	1004.4448v1	3

Figure 23. Girvan-Newman Clustering Group (Nodes with Highest Internal Degree)

K-core is a "maximal group of actors, all of whom are connected to some number (k) of other group members."[285] According to Naval Postgraduate School Professor Sean Everton, "Girvan-Newman begins with a connected network and then strategically removes ties, a process that partitions the network into an increasing number of clusters."[286] The key to this algorithm is the notion of edge betweenness, in which the algorithm estimates the ties, or betweenness centrality of the edges. In other words, it measures the shortest path between the authors.

I have pulled this group and searched each of their affiliated schools, organizations, and particular fields of research and each of them are from organizations around the world. Guillermo Sapiro has over 64,000 citations on Google Scholar and one of his most recent studies in 2020 on deep neural networks relates to detecting adversaries using influence and nearest neighbors. Group 1 reveals the top 10 authors or nodes and separate from the other Girvan-Newman groups. In Table 7, the top 10 AI experts who have written papers are shown, including associated schools, organizations, and research topics.

Table 7. Group 1: Top 10 AI Experts with an Internal Node Count of 158

Authors	School	Organization	Research
Guillermo Sapiro	Duke University	Duke Electrical and Computer Engineering; the Office of Naval Research Young Investigator Award in 1998	Image and video processing, data analysis, ML, medical imaging, CV
Michael Bronstein	Imperial College London / University of Lugano	Chair in Machine Learning and Pattern Recognition; Professor of Informatics at USI Lugano, Switzerland	Geometric deep learning, ML, shape analysis, geometry processing graphs
Yann LeCun	New York University	Chief AI Scientist at Facebook & Silver Professor at the Courant Institute	AI, ML, CV, robotics, image compression
Jonathan Masci	Università della Svizzera Italiana	Director of Deep Learning @ http://nnaisense.com/	Deep Learning, ML, CV
Laurent Najman	Laboratoire d'Informatique Gaspard Monge / Université Paris-Est	University of Paris	CV and Image processing
Mariano Tepper	Intel Labs	Intel Labs	Image processing, CV, PR, ML
Alexander M. Bronstein	Technion, Israel Institute of Technology	Technion	Numerical geometry, CV, ML, deformable shapes, sparse models
Juergen Schmidhuber	The Swiss AI Lab IDSIA / USI & SUPSI	Co-director of the Dalle Molle Institute for Artificial Intelligence Research in Manno, Switzerland	DL, Neural Networks, ML
Ron Kimmel	Technion, Israel Institute of Technology	Technion, Israel	Image processing, CV, shape analysis, medical imagery, metric geometry
Arthur Szlam	Facebook	Facebook AI Research	Image modeling, spectral networks, geometric DL, video language modeling

[285] Sean Everton, *Disrupting Dark Networks* (Cambridge, MA: Cambridge University Press, 2012), 182.

[286] Everton, 195.

By using ORA combined with researching on Google Scholar, this social network analysis algorithm illuminates hidden talent that the DOD and United States Navy can leverage to maintain its competitive advantage over other adversaries. In particular, the DOD can visualize and seek well-connected authors and co-authors who are researching today on deep neural networks that can or will be used in the future for counter-AI tools or future work that can be further researched and connected with relevant DOD components. Figure 24 shows social network analysis using the software ORA and data set derived from arXiv.

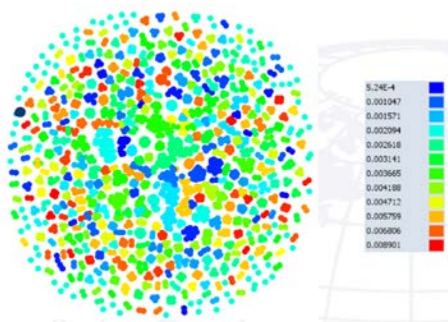

Figure 24. K-Core Subgroup of CV and PR

Figure 25 shows the group statistics and large group statistics of AI researchers studying topics on computer vision and pattern recognition. The group statistics helps visualize how many groups and how many groups of two, three or more are collaborating.

Group Size Statistics	
Number of groups	11,658
Number of isolate groups	0
Number of dyad groups	5,173
Number of triad groups	320
Larger group	74
Larger Group Statistics	
Number of larger groups	337
Minimum size	4
Maximum size	16
Average size	4.75
Std.dev size	1.76

Figure 25. K-Core Group Size and Large Group Statistics

However, this data set is limited to mostly one author to one author on a research paper in which 83 percent of the nodes are tied to one other node.

B. RESULTS: ANALYSIS OF SPECIFIC NETWORKS

In the Machine Learning Group 1, four main nodes were taken out of the whole network for further analysis. This group showed the most connections, as depicted in light blue, blue, lime green, and gold, as shown in Figure 26.

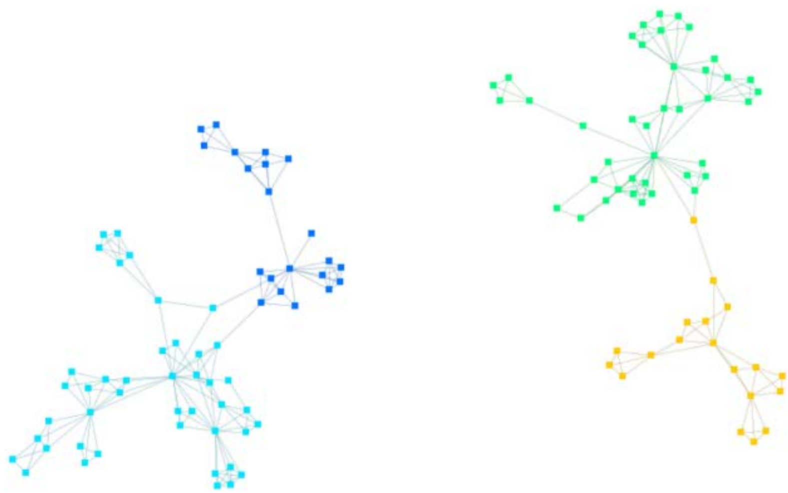

Figure 26. Top Connected AI and Machine Learning Researchers Derived ArXiv and Visualized through ORA

Guillermo Sapiro (ML, CV; over 64,000 scholarly citations), Yann LeCun (ML, CV, image compression; over 140,000 citations), Michael Bronstein (geometric deep learning; over 14,000 citations), and Jonathan Masci (AI, ML, CV; over 5,000 citations) appear to be the center nodes with the most connections. French mathematician and École Normale Supérieure Professor Stephane Mallat (over 100,000 citations) is represented by a center gold node and appears to be a potential bridge between Sapiro's and LeCun's networks, as show in Figure 27. If severed, these two would not be connected any longer. However, if one wanted to be connected to both of their networks, ORA's algorithm has revealed Mallat is the "go-to" person regarding this field of research in AI. The farthest in distance of connected nodes appears to be Rama Chellappa and her network. Mallat has researched heavily on facial and pattern recognition, specifically mathematics on high degree approximations and deep convolutional networks for image identification and classification (see Figure 27).

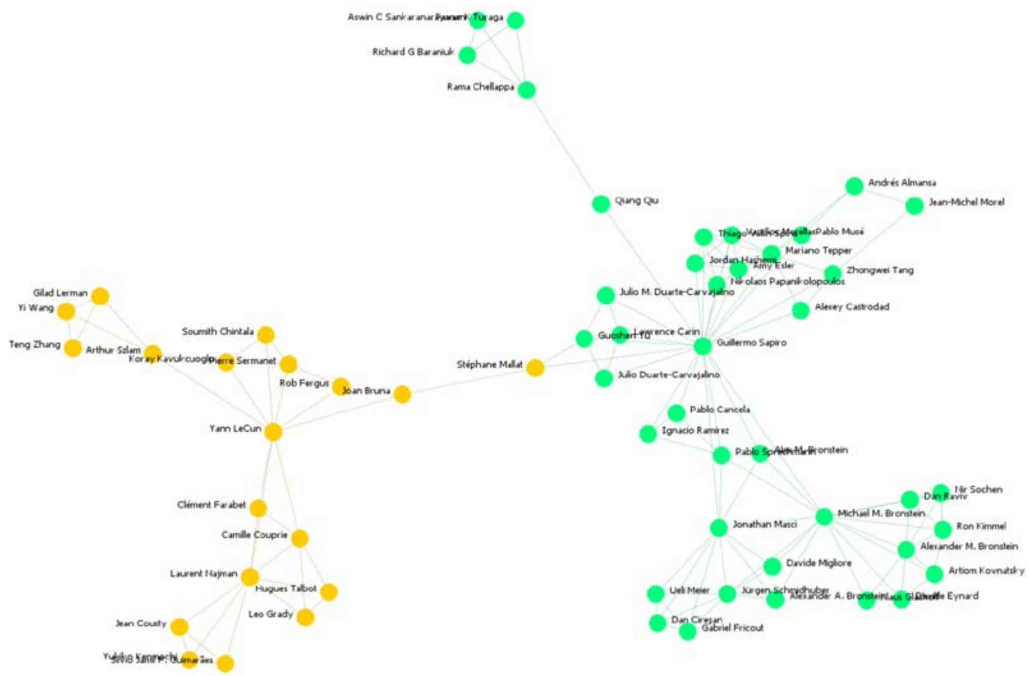

Figure 27. Social Network Analysis Shows Stephane Mallat as a Bridge Between LeCun’s and Sapiro’s Networks

In CV and PR, a more well-connected and smaller part of the whole network was separated out to visually display a few central nodes. Depicted by the pink arrows, the AI authors Zhouchen Lin, Allen Yang, and Yi Ma are limited in centrality, betweenness, brokerage potential, clustering coefficient, and so on and so forth. Clearly, this network is not very dense. Zhouchen Lin is the Vice President of Samsung Research and works at Peking University in China. Allen Y. Yang is a research expertise in the fields of CV, robotics, and pattern recognition at Berkeley University as the Chief Scientist, Fung Institute for Engineering Leadership and Executive Director for the Center of Augmented Cognition. Yi Ma is a Berkeley professor with an expertise in Artificial Intelligence (AI)

Control, Intelligent Systems, and Robotics (CIR) Signal Processing (SP) Computer Vision Compressive Sensing. These top three nodes show a direct tie between the United States and China both heavily researching in AI, but with very low out-degree.

However, this specific network reveals heavy international connections. For instances, Lin is connected to Shuicheng Yan (center left, central node) who is a professor at National University of Singapore. Yan is connected to a U.S. Johns Hopkins and biomedical engineer Professor Rene Vidal (Figure 28).

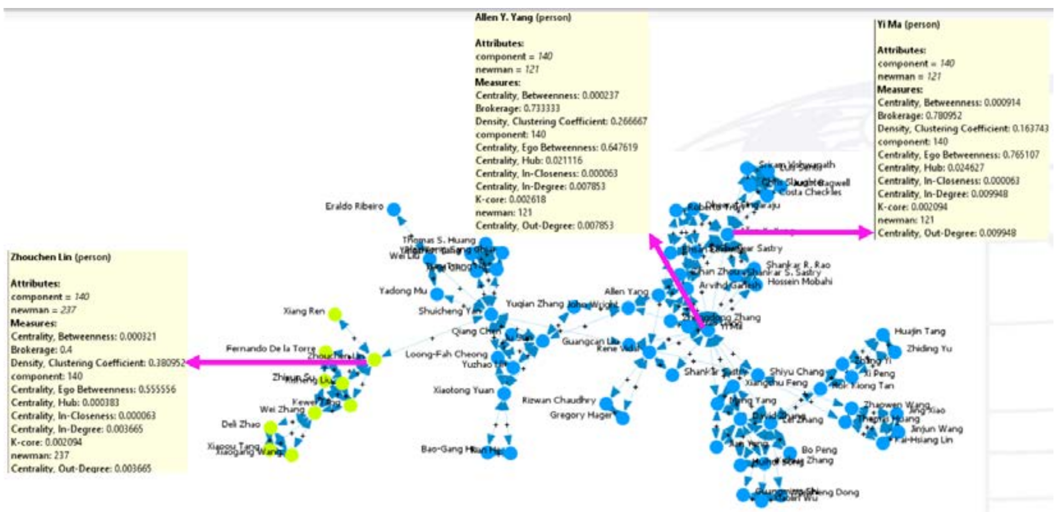

Figure 28. Low Density of CV and PR Researchers, But Well Connected Internationally

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