HOMELAND DEFENSE OF HAWAII: PROTECTING THE STATE AGAINST THE EVOLVING BALLISTIC MISSILE THREAT PRESENTED BY CHINA, RUSSIA, AND NORTH KOREA

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China, Russia, and North Korea continue to invest heavily in ballistic missile technology, expanding their nuclear weapon employment capabilities and presents a persistent threat to the safety and security of America. Due to their relative proximity to Hawaii, they pose a significant challenge to the homeland defense mission. A comprehensive evaluation of near-peer threat countries and rogue states' ballistic missile capabilities provide the necessary data to assess the effectiveness of the current United States' ballistic missile defense program. A detailed analysis of the global missile defense system examines the sensors, communications, and kill vehicle interceptors required to detect, identify, track, target, and defeat adversary ballistic missiles during launch, boost, mid-, and terminal-phases of flight. The focus of the investigation is the Pacific region and the ability to defend Hawaii against a ballistic missile attack from China, Russia, or North Korea. This research paper will attempt to identify any potential gaps in the layered missile defense system by answering the primary question: How does America defend Hawaii against the evolving ballistic missile threats posed by China, Russia, and North Korea?

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

HOMELAND DEFENSE OF HAWAII: PROTECTING THE STATE AGAINST THE EVOLVING BALLISTIC MISSILE THREAT PRESENTED BY CHINA, RUSSIA, AND NORTH KOREA, by Nicholas C. Danielson, 75 pages.

China, Russia, and North Korea continue to invest heavily in ballistic missile technology, expanding their nuclear weapon employment capabilities and presents a persistent threat to the safety and security of America. Due to their relative proximity to Hawaii, they pose a significant challenge to the homeland defense mission. A comprehensive evaluation of near-peer threat countries and rogue states' ballistic missile capabilities provide the necessary data to assess the effectiveness of the current United States' ballistic missile defense program.

A detailed analysis of the global missile defense system examines the sensors, communications, and kill vehicle interceptors required to detect, identify, track, target, and defeat adversary ballistic missiles during launch, boost, mid-, and terminal-phases of flight. The focus of the investigation is the Pacific region and the ability to defend Hawaii against a ballistic missile attack from China, Russia, or North Korea.

This research paper will attempt to identify any potential gaps in the layered missile defense system by answering the primary question: How does America defend Hawaii against the evolving ballistic missile threats posed by China, Russia, and North Korea?

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TABLE OF CONTENTS

Page

ACRONYMS

C2	Command and Control
C2BMC	Command and Control, Battlespace Management, and Communications
BM	Ballistic Missile
BMD	Ballistic Missile Defense
BMDS	Ballistic Missile Defense System
DoD	Department of Defense
DF	Dongfeng
DSP	Defense Support Program
EKV	Exo-atmospheric Kill Vehicle
GBI	Ground-based Interceptor
GCC	Geographic Combatant Command
GFC	Ground-based Midcourse Defense Fire Control
GMD	Ground-based Midcourse Defense
HD	Homeland Defense
HGV	Hypersonic Glide Vehicle
ICBM	Intercontinental Ballistic Missile
INF	Intermediate-Range Nuclear Forces
IRBM	Intermediate-Range Ballistic Missile
MD	Missile Defense
MDA	Missile Defense Agency
MDR	Missile Defense Review
MIRV	Multiple Independently Targetable Re-entry Vehicle

MTCR	Missile Technology Control Regime
NATO	North Atlantic Treaty Organization
NDS	National Defense Strategy
NMD	National Missile Defense
NPR	Nuclear Posture Review
NSS	National Security Strategy
OPIR	Overhead Persistent Infrared (OPIR)
PAV	Payload Launch Vehicle
PRC	People's Republic of China
SBIRS	Space-based Infrared System
SLBM	Submarine-launched Ballistic Missile
SRBM	Short-Range Ballistic Missile
SSBM	Ballistic Missile Submarine
STSS	Space Tracking and Surveillance System
UEWR	Upgraded Early Warning Radar
USINDOPACOM	United States Indo-Pacific Command
USNORTHCOM	United States Northern Command
XBR	X-band Radars

ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

Advancements in ballistic missile (BM) technology continue to plague America's homeland security mission. The main challengers, China, Russia, and North Korea, field a large arsenal of advanced missiles, including variants that can reach the United States (U.S.). China and Russia consistently confront America's security by contesting U.S.' influence, interests, and global power. In addition to near-peer threats, the rogue nation of the Democratic People's Republic of Korea is determined to challenge the Pacific region, threatening America's safety (U.S. President 2017, 2).

The 2017 National Security Strategy (NSS) recognizes the growing BM threat, listing the first vital interest as the "fundamental responsibility to protect the American people, the homeland, and the American way of life." (U.S. President 2017, 4) China, Russia, and North Korea continually investing heavily in BM technology to overwhelm America's defenses by seeking longer ranges, faster employment speeds, higher altitudes, and employing multiple warheads designed to defeat BM defenses. The scientific advancements in BM technology create an enduring and complex problem for the homeland defense (HD) of America.

Background

The NSSs foundation focuses on nuclear deterrence by preserving peace and stability through discouraging aggression against the U.S.. China, Russia, and North Korea all maintain an arsenal of BMs that threaten the State of Hawaii. In the NSS, President Donald Trump asserts, "We will defend our country, protect our communities, and put the safety of the American people first." (U.S. President 2017, 7) To accomplish this task, America must be able to defend Hawaii against evolving BM threats.

The 2018 National Defense Strategy (NDS) key objectives are defending the homeland from attack, deterring adversaries from aggression, and maintaining favorable regional balances of power in the Indo-Pacific, Europe, the Middle East, and the Western Hemisphere (DoD 2018, 4). HD encompasses the physical region that includes the continental U.S., Alaska, Hawaii, U.S. territories, and surrounding territorial waters and airspace (U.S. Joint Chiefs of Staff 2018, I-1). According to Joint Publication 3-27, the anticipated use of fires is required to protect the homeland against a BM strategic attack (U.S. Joint Chiefs of Staff 2018, III-4).

China's political goals threaten to displace the U.S. in the Indo-pacific by reordering the region in its favor and presents the highest persistent strategic threat to American interests (Davidson 2019). China continues to collect and exploit data at an unprecedented rate and attempts to exercise power without regard to existing bodies of law including infiltration, corruption, and exploitation (U.S. DoD 2019, III). China is expanding its military capabilities by investing heavily in growing and diversifying its nuclear arms (U.S. President 2017, 25).

According to the Center for Strategic and International Studies (CSIS), "China has the most active and diverse BM development program in the world, upgrading its missile forces in number, type, and capability." (Missile Defense Project [MDP] 2018a) The People's Republic of China (PRC) exhibited several cruise and BMs during a recent parade celebrating their 70th anniversary, showcasing the Ju Lang-2 (JL-2) Submarine-Launched Ballistic Missile (SLBM), Dong Feng-31(DF-31), and Dong Feng-41 (DF-41)

Intercontinental Ballistic Missiles (ICBMs) (Williams and Dahlgren 2019). Along with China, Russia also maintains a vast BM capability.

Russia's goal is to restore its great power status and establish spheres of influence near its borders by seeking to divide the alliances between America and partner states. During a U.S. House Armed Services Committee Testimony, Indo-Pacific Commander, Admiral Phil Davidson stated, "Moscow regularly plays the role of spoiler, seeking to undermine U.S. interests and impose additional costs on the U.S. and our allies whenever and wherever possible." (Davidson 2019, 1) Russia's substantial investments in new military capabilities, including nuclear systems, remain the most significant existential threat to the U.S. (U.S. President 2017, 2). The Center for Strategic and International Studies (CSIS) states, "Russia boasts the widest inventory of ballistic and cruise missiles in the world…significant modernization efforts include new heavy ICBMs, as well as ground-launched cruise missiles." (MDP 2018c) Several of Russia's ground-based ICBMs have ranges over 11,000 km, well capable of reaching the U.S. In addition to near-peer competitors, rogue states also threaten America's security.

North Korea continues developing nuclear weapons and missiles to threaten the entire planet. Admiral Davidson further testified that "Until the nuclear situation is resolved on the peninsula, North Korea will remain our most immediate threat." (Davidson 2019, 1) Military expansion and technological advances in BMs, nuclear capabilities, cruise missiles, and hypersonic vehicles continually degrade U.S. advantages. North Korea remains one of the most rapidly developing threats to national security due to their unprecedented pace of missile testing to include upgraded BMs, sea launch testing, and recent space exploration (MDP 2018b).

Significance

The NDS nests within the priorities of the NSS, with both listing HD as a top concern. In 1898, the former Assistant Secretary of the U.S. Navy, Theodore Roosevelt, argued that Hawaii's strategic location would establish the U.S. military as a world superpower (Shepardson 1998). Hawaii's position in the center of the Pacific would help to expand America's operational reach. Hawaii's vulnerability due to the proximity and range to threat nations makes it a viable target for a BM attack. According to the 2019 U.S. Census, Hawaii is home to over 1.41 million U.S. citizens and contains numerous critical infrastructures to include: nineteen military bases, multiple early warning radars, the 613th Air Operations Center (AOC), and the United States Indo-Pacific Command (USINDOPACOM) (Hawaii Population 2020).

The 154th Wing is located on Joint Base Pearl Harbor-Hickam (JBPHH), enabling the Pacific region with global reach, global strike, and global power capabilities through the employment of multiple platforms. The 154th Wing's organic assets include airlift, air-refueling, and fighter aircraft, "Providing organized, trained units to protect Hawaii's citizens and property, preserve peace, and ensure public safety…to provide operationally ready combat units in time of war." (Hawaii Air National Guard, 2020)

Early Warning Radars detect aircraft, cruise, and BM threats to identify tracks of interest (TOIs). The 169th Air Defense Squadron, located at Wheeler Army Airfield, focuses on C2 of assigned airspace, managing numerous joint service aircraft, close air support operations, intelligence gathering, and airlift operations (Air National Guard 2020). Additionally, a key component to the Ballistic Missile Defense System (BMDS), the Sea-Based X-Band Radar (SBX-1), is periodically located in Hawaii. The SBX-1 is a floating, self-propelled mobile active electronically scanned array early-warning radar station designed to provide early warning and tracking of BMs (Missile Defense Agency [MDA] 2008, 3).

The 613th AOC, assigned to Headquarters, Pacific Air Forces, JBPHH, provides C2 of joint air operations and multi-domain fires, supporting operations throughout the Indo-Asia-Pacific region (Pacific Air Forces 2014). The AOC provides the Commander of Air Force Forces, Theater Joint/Combined Force Air Component Commander (T-J/CFACC), and the Theater Area Air Defense Commander (T-AADC) with C2 of joint operations through integrated planning, target identification, weaponeering, sortie allocation, air tasking order production, mission execution management, and operational-level evaluations (Pacific Air Forces 2014).

USINDOPACOM is one of the six geographic combatant commands (GCCs) in charge of employing and integrating the U.S. Air Force, Army, Marine Corps, and Navy forces within the USINDOPACOM area of responsibility (AOR) in order to achieve national security objectives. The region is heavily militarized, containing seven of the world's ten largest militaries, with five having declared nuclear capabilities (USINDOPACOM 2020).

Primary and Secondary Research Questions

The primary research question is: How does America defend Hawaii against the evolving BM threats posed by China, Russia, and North Korea? To fully understand and address this question, the secondary questions are:

1. What are the current BM capabilities that China, Russia, and North Korea possess? What is the likelihood of a BM attack against Hawaii?

2. What capabilities does the U.S. have to detect, track, and defeat a BM attack against Hawaii?

Definitions

The definition of key terms provides a common baseline understanding throughout this paper.

Aegis BMDS. Aegis Ballistic Missile Defense (BMD) is the naval component of the BMDS that incorporates the SPY-1 radar and Standard Missile-3 (SM-3) to intercept short- to intermediate-range BMs (IRBMs) during the midcourse phase of flight (U.S. DoD 2016a).

Aegis Ashore. Land-based Aegis BMDS designed to address regional BM threats, utilizing a SPY-1 radar and SM-3 (U.S. DoD 2016a).

BM. Any missile that does not rely upon aerodynamic surfaces to produce lift and follows a ballistic trajectory when thrust is terminated (U.S. Joint Chiefs of Staff 2017, I-2).

BMD. JP 3-27 defines BMD as the incorporated systems necessary to detect, deter, prevent, and defeat BM threats (U.S. Joint Chiefs of Staff 2018, III-18).

Early Warning Radar (EWR). Early warning radars detect BM attacks and conduct general space surveillance and satellite tracking. The system rapidly discriminates between vehicle types, calculates launch and impact points, performs scheduling, data processing, and communications requirements to provide early warning of inbound BMs (Air Force Space Command Public Affairs 2017).

ICBM. ICBMs are BMs that can travel thousands of miles from one continent to another, defined as having ranges in excess of 5,500 kilometers or 3,420 miles (The Associated Press 2017).

Global Missile Defense (GMD). According to JP 3-01, GMD is defined as "missile defense operations, activities, or actions that affect more than one GCC and require planning synchronization among the affected commands to deter and prevent attacks, destroy enemy missiles, or nullify or reduce the effectiveness of an attack." (U.S. Joint Chiefs of Staff 2017, I-2)

Ground-Based Midcourse Defense. Ground-based Midcourse Defense employs integrated communications, fire control networks, globally deployed space- and terrestrial-based sensors, and Ground-Based Interceptors capable of detecting, tracking, and destroying BM threats (U.S. DoD 2015).

HD. JP 3-27 defines HD as the protection of U.S. sovereignty, territory, domestic population, and critical infrastructure against external threats and aggression or other threats, as directed by the President of the U.S. HD is executed by detecting, deterring, preventing, and defeating threats as far away from the homeland as feasible (U.S. Joint Chiefs of Staff 2017, vii & I-3).

MDA. MDA is a research, development, and acquisition agency within the DoD. Develops BMDs technology and programs to address the challenges of evolving threats. The goal is to develop, test, and prepare for the deployment of missile defense systems to engage all classes and ranges of BM threats (U.S. Joint Chiefs of Staff 2017, B-6).

Multiple Independently Targetable Re-entry Vehicles (MIRVs). MIRVs permit a single missile to employ multiple nuclear warheads to various targets up to 1,500 km away, creating a difficult problem for BMD (The Center for Arms Control and Non-Proliferation 2017).

Patriot Advanced Capability (PAC)-3. PAC-3 systems are hit-to-kill missiles providing simultaneous air and missile defense capabilities against threats in the terminal phase of flight (U.S. DoD 2016c).

Terminal High Altitude Area Defense (THAAD). Globally transportable, rapidly deployable capability to intercept and destroy BM inside or outside the atmosphere during their final, or terminal, phase of flight (U.S. DoD 2018a).

Assumptions

Throughout the research process, the author made the following assumptions:

1. China, Russia, and North Korea possess the capability to employ a BM attack on Hawaii. This assumption is necessary to determine America's capability to detect and defend against an inbound BM attack.
2. The next assumption relies that unclassified sources reflects current information, accurate data, and sufficiently addresses the research questions. This assumption was necessary to complete the research by comparing pertinent facts and figures of threat and friendly capabilities.
3. Finally, the assumption that only U.S. assets are available to defend Hawaii's homeland during the time of attack. This assumption was necessary due to the limited access to partner capabilities and remains the U.S.' primary requirement for HD.

Limitations

1. The primary limitation is the security classification. This paper remains at the UNCLASSIFIED level due to the research available and analysis conducted. As a result, the study did not include higher-level classifications of threat capabilities, homeland defensive measures, and current operational plans.
2. The secondary limitation pertains to the latency of information. Due to the pace of evolving threats and advancements in technology, data on weapon systems are always in flux. This research will utilize present facts and figures to compare and contrast BM and defensive capabilities.

Scope

In order to narrow the scope of this study, this thesis focuses only on the BM threats to the State of Hawaii, imposing the following delimitations:

1. This research only covers the BM threat to Hawaii presented by China, Russia, and North Korea. China and Russia currently possess strategic bombers. The H-6, Tu-160 Blackjack, and Tu-95MS Bear can target Hawaii with air-launched cruise missiles (Kristensen & Norris 2018). However, this paper will not address the cruise missile threats launched from air platforms or any Hypersonic Glide Vehicle (HGV) weapons.
2. This thesis will not cover threats to other locations as listed in the homeland defense mission other than Hawaii.
3. This analysis does not discuss the cyber threat or any other capabilities that China, Russia, or North Korea may possess to disguise or delay the detection and engagement of a BM attack.

Conclusion

The purpose and scope provide a basic understanding of the primary and secondary research questions and justifies the significance of this research. The definition of key terms ensures adequate comprehension of the thesis material throughout the paper. The purpose of this paper is to examine the BM threat to Hawaii to ensure the safety and security of American lives against a persistent danger. The scope narrows the topic to ensure a detailed examination of the thesis question: How does America defend Hawaii against the evolving BM threats posed by China, Russia, and North Korea? This paper will also investigate the auxiliary questions by researching the critical BM threats and U.S. BMD capabilities.

CHAPTER 2

LITERATURE REVIEW

Introduction

The research for this study consisted of three primary sources: government publications, reports, and historical articles. Government guidance includes strategic guidance, joint publications, and individual service doctrine. The strategic guidance identifies the requirements for HD at the national level and defines priorities, roles, and responsibilities. Joint publications determine direction and authorities outlined by the Joint Chiefs of Staff and provides a common language between services. Service doctrines discuss how each service responds to HD and describes best practices, processes, and procedures.

Reports prepared for Congress and other government agencies cover threats from China, Russia, and North Korea's BMs, including launch requirements, ranges, altitudes, speeds, and limitations. Information gathered from unit websites will contain HD requirements and associated capabilities for executing the HD mission. Joint and service doctrine details best practices, processes, procedures, and establishes a common language between services. Articles will provide historical evidence of previous BM employment results achieved from previous tests and evaluations for both threat countries and America's BMD systems.

Government Guidance

The NSS illustrates the President's goal of national security by placing the safety, interests, and the well-being of Americans first. The NSS lists HD as the highest priority calling for a layered missile defense system capable of defending the homeland against missile attacks. The NSS emphasizes North Korea's expansion of military weapons, expending hundreds of millions of dollars on nuclear, chemical, and biological weapons threatening our homeland (U.S. President 2017, 46-48). China and Russia continually invest in technological research, threatening our critical infrastructure and security.

The NSS also stresses the importance of deterrence, stating that the U.S. must "Preserve peace through strength by rebuilding our military to deter adversaries." (U.S. President 2017, 4) The U.S. must increase resources to convince adversaries that America can and will defeat them, discouraging potential enemies by modernizing current capabilities, acquiring new technology, improving readiness, expanding the military, and affirming the political will to win. The requirement to invest in military capabilities is requisite to building a force that facilitates the prevention of future attacks. The national objective is to ensure HD without disrupting the longstanding strategic relationships with Russia or China (U.S. President 2017, 8). The NSS also highlights the necessity for better acquisition processes to acquire the necessary equipment and capabilities required to build the force, maintain readiness, and improve integration between all services.

The NDS reiterates the necessity of HD and defines the responsibilities, roles, and functions of the military services. The DoD's enduring mission is to provide combat-credible military forces required to deter war and win if needed to protect the safety and security of the U.S. (U.S. DoD 2018c, 1). The NDS summarizes the threat posed by China, Russia, and North Korea, recognizing the absolute necessity to compete, deter, and win through building a more lethal force capable of defeating a BM attack against our homeland (U.S. DoD 2018c, 1).

Joint Publication 3-27: *HD*, identifies United States Northern Command (USNORTHCOM) and USINDOPACOM roles and responsibilities to deter BM attacks on the U.S., its territories and bases within their respective Area of Responsibility (AORs), and other areas as directed by the President or Secretary of Defense (SecDef). Global Missile Defense (GMD) requires centralized execution with positive direction from the weapons release authority (WRA). WRA is the authority delegated from the president to use certain weapons against ICBMs. USINDOPACOM supports USNORTHCOM and the WRA for homeland BMD using the Global Missile Defense (GMD) system within the USINDOPACOM AOR (U.S. Joint Chiefs of Staff 2018, III-19).

JP 3-27 also addresses the Integrated Tactical Warning and Attack Assessment (ITW/AA), which provides warning after initiation of a strategic or tactical aerospace threat event based on an evaluation of information from all available resources. The main purpose is to provide timely, reliable, and unambiguous warning information of BM, space, and air attacks on North America. The United States Strategic Command (USSTRATCOM) provides space surveillance, nuclear detonation detection, and BM warning to North American Aerospace Defense Command (NORAD). NORAD executes assigned missions for HD by shifting priorities of the ITW/AA systems for attacks against North America (U.S. Joint Chiefs of Staff 2018, C-2 to C-3). China, Russia, and North Korea all maintain the capability to employ a chemical, biological, radiological, and nuclear (CBRN) attack utilizing BMs. JP-37 further states, “The threat of a BM attack against the homeland is the one strategic threat by a rogue state that would require the use of fires to protect the homeland.” (U.S. Joint Chiefs of Staff 2018, C-2 & III-4)

U.S. HD must be able to detect, deter, prevent, and defeat BM threats to protect the U.S. population and critical infrastructure. Space operations are enabling activities for BMD, utilizing space-based sensors and surveillance, critical for early warnings, intelligence gathering, and tracking BM attacks. The JP also describes the role of the MDA regarding research, development, and acquisition processes within the DoD (U.S. Joint Chiefs of Staff 2018, III-4 to III-19).

JP 3-01, *Countering Air and Missile Threats* describes the joint planning process for HD and details the process for C2 required to counter air and missile defense. The integration of various BMD systems provides defense-in-depth and creates the possibility for multiple engagements during a BM attack, increasing the probability of success. The Unified Command Plan (UCP) directs that the responsibility of the combatant commanders (CCDRs) is to “detect, deter, and prevent attacks against the U.S., its territories and bases, and employ appropriate force to defend the nation should deterrence fail” (U.S. Joint Chiefs of Staff 2017, I-6 to I-8).

JP 3-01 defines the homeland as the continental U.S., Alaska, Hawaii, U.S. territories, and the surrounding territorial waters and airspace. The commands tasked with HD are USNORTHCOM, North American Aerospace Defense Command (NORAD), and USINDOPACOM. The Commander, United States Indo-Pacific Command (CDRUSINDOPACOM), is responsible for all HD missions in the USINDOPACOM AOR, including Hawaii (U.S. Joint Chiefs of Staff 2017, I-8).

Firing orders and guidance from the Area Air Defense Commander (AADC), Regional Air Defense Commander (RADC), or Sector Air Defense Commander (SADC), are passed to the firing units and requires coordination and deconfliction of BM engagements. Engagements in the exo-atmospheric may be executed by the Aegis weapon system and the Terminal High Altitude Area Defense (THAAD) system, through coordination and deconfliction provided by the appropriate tactics, techniques, and procedures (TTPs) (U.S. Joint Chiefs of Staff 2017, II-14 to II-16).

The SecDef establishes command and support relationships for GMD and cross-AOR operations to mitigate the complex threat of ICBMs and the capability to execute cross-AOR attacks. The supported commander is where the BM attack will impact; all others are in supporting roles. The CDRUSSTRATCOM has the responsibility for the overall coordination of MD planning processes for multi-AOR BMD. Weapons Release Authority (WRA) is the engagement authority to utilize a ground-based midcourse defense (GMD) system against BM threats, and is unique to HD (U.S. Joint Chiefs of Staff 2017, II-16 & III-14).

Space operations offer significant capabilities for BMD, providing BM launch warning, attack assessments, sensor cueing, locations, impact areas, tracking, timing, and potential jamming. Space support is coordinated through USSTRATCOM for user requirements and provides either strategic or theater missile warnings (U.S. Joint Chiefs of Staff 2017, III-21). Strategic missile warnings provide notification of an attack against North America or allied and partner nations. Theater missile warnings provide notifications to operational command centers and warfighters of potential threats impacting an area of responsibility (AOR), area of interest (AOI), or joint operations area (JOA) (U.S. Joint Chiefs of Staff 2017, III-22).

Due to the potential ranges of BMs, GMD requires decentralized execution delegating tasking and engagement authority to the lowest possible levels in accordance with rules of engagement (ROE) and the area air defense plan (AADP). The one "exception to decentralized execution of MD is for homeland MD, using the GMD system, which requires positive direction from the WRA delegated from the President" (U.S. Joint Chiefs of Staff 2017, III-23). Planning is instrumental and required to set clear policy guidelines, shared situational understanding, minimize system latency, and the ability to synchronize effort across the vast AORs (U.S. Joint Chiefs of Staff 2017, III-23). The main communication link for GMD is the BMD COMNET, comprised of numerous distinct communications systems including both military and commercial satellite capabilities and the Defense Information System Agency-provisioned terrestrial services (U.S. Joint Chiefs of Staff 2017, III-26).

Reports

The 2018 Nuclear Posture Review (NPR) introduces the U.S. nuclear policy and strategy for nuclear deterrence, discusses different capabilities of nuclear employment, and identifies current and future BM threats. The first strategic priority for the U.S. national nuclear policy is to deter potential adversaries from a nuclear attack of any scale. The primary foundation of nuclear strategy has been deterrence with the implementation of several treaties in the past 70 years. The 1991 Strategic Arms Reduction Treaty (START), the 2002 Strategic Offensive Reduction Treaty, the 2010 New START Treaty, and the Nuclear Non-Proliferation Treaty are attempts to reduce and minimize nuclear tensions (U.S. DoD 2018b, I, XVI, & 20).

Nuclear deterrent maintenance costs are approximately three percent of the annual defense budget. The U.S. faces threats with unprecedented ranges and capabilities, including conventional, chemical, biological, nuclear, space, and cyberspace. The U.S.

seeks to maintain stable relations with China and Russia through diplomacy, extending deterrence by displaying the strength and commitment of the U.S. capabilities to deter, or defeat if necessary, any potential adversary threat (U.S. DoD 2018b, I to VIII).

Ensuring deterrence, the U.S. operates fourteen OHIO-class BM submarines (SSBMs), with plans to replace them with a minimum of twelve COLUMBIA-class SSBNs. Maintained for nuclear avoidance, the U.S. deployed 400 single-warhead Minuteman III missiles throughout the states in underground silos. The U.S. Air Force maintains the ability to employ global power through a variety of long-range bombers, air-refueling, C2 platforms, and air superiority fighters (U.S. DoD 2018b, x).

China's relentless military modernization continues to enhance the capabilities of its nuclear force. China continues to develop its strategic ICBMs, showcasing the Dong Feng-5 (DF-5) silo-based ICBM and their SLBMs, both missiles capable of targeting the U.S. (U.S. DoD 2018b, 2 & 11). The U.S. seeks to enhance relations with China through an open and transparent understanding of respective nuclear policies, doctrine, and capabilities. Improving transparency reduces the risk of miscalculation and misperception, resulting in escalating nuclear tensions (U.S. DoD 2018b, 7).

Russia continues to expand its strategic and non-strategic nuclear forces, emphasizing the potential coercive and military uses of nuclear weapons in its doctrine. Russia assesses the threat of nuclear escalation or actual first use will de-escalate the situation in advantageous terms for Russia. The U.S. seeks to maintain strategic dialogue to manage nuclear competition and minimize nuclear risks (U.S. DoD 2018b, 7-8). Russia's ability to employ BM nuclear warheads capable of ranging America's homeland and a strategy of striking first creates a significant, viable threat to Hawaii's security.

North Korea's persistent pursuit of nuclear weapons and BM capabilities violate United Nations Security Council resolutions. North Korea reaffirms its commitment to developing its nuclear arsenal and acquiring the ability to strike the U.S. with nuclear-armed BMs (U.S. DoD 2018b, 3 and 11). The U.S. DoD states, "North Korea's illicit nuclear program must be completely, verifiably, and irreversibly eliminated, resulting in a Korean Peninsula free of nuclear weapons" (U.S. DoD 2018b, 12). China, Russia, and North Korea all maintain viable BM threats capable of striking the U.S. homeland. Should deterrence fail, the U.S. must be able to detect, track, and defeat a BM attack.

The 2019 Missile Defense Review (MDR) provides an in-depth description of the MD capabilities and limitations of the U.S., stating potential adversaries are modernizing existing missile systems, securing new and improved technology, and integrating offensive missiles more frequently in exercises and war planning (U.S. DoD 2019, I to XVIII). The MDR stresses the importance of space-based sensors and surveillance required for early detection, launch, tracking, timing, targeting, and destroying BMs (Karako 2019, 1-5). It describes the national level threats from China, Russia, and North Korea and discusses the potential risks arising from a BM launch.

According to the MDR, China retains 75-100 ICBMs, possesses four advanced JIN-class SSBM, and can threaten the U.S. with approximately 125 nuclear warheads. North Korea is accelerating field missiles and is capable of striking U.S. territories in the Pacific Ocean, investing considerable resources in its BM and nuclear programs. Russia views the U.S. as a principal threat to its political ambitions, routinely conducting exercises involving nuclear strikes against the U.S. homeland. Under the 2010 New

START Treaty, Russia is limited to 700 deployed ICBMs and 1,550 strategic nuclear warheads (U.S. DoD 2019, II to III).

The MDR states, “The U.S. will field, maintain, and integrate three different means of missile defense to identify and exploit every practical opportunity to detect, disrupt, and destroy a threatening missile prior to and after its launch” (U.S. DoD 2019, III). The three means include an active missile defense to intercept BM is all phases of flight, a passive defense to mitigate effects of BMs, and attack operations to defeat BMs before launch (U. S. DoD 2019, VIII). The MDR also presents U.S. capabilities and limitations for BMD. The MDR covers the Ground-based Midcourse Defense (GMD) system, the Sea-Based X-Band (SBX) radar, Aegis BMD system, Patriot Advanced Capability-3 (PAC-3), and the Terminal High Altitude Area Defense (THAAD) (Karako 2019, 7).

The GMD is capable of engaging long-range BMs in the mid-course phase of flight by utilizing Ground-Based Interceptors (GBIs), located at Ft. Greely, Alaska and at Vandenberg Air Force Base, California. The THAAD system engages short-, medium-, and intermediate-range missiles, located in seven batteries throughout the U.S., Guam, and the Republic of Korea (ROK). The Aegis Sea-based missile defense and Aegis Ashore (land-based) protects against regional BMs by employing the SM-3 and SM-6 missiles hit-to-kill technology. PAC-3 are deployable systems used to defend against Short-Range Ballistic Missiles (SRBMs) and cruise missiles (U.S. DoD 2019, X-XII).

The 2019 Report to Congress of the U.S.-China Economic and Security Review Commission covers testing, development, capabilities, and future research that China is currently modernizing. In February 2019, the U.S. withdrew from the Intermediate-Range

Nuclear Forces (INF) Treaty ending the 1987 treaty meant to prevent destabilization of the nuclear arms race (U.S. Economic and Security Review Commission 2019, 334).

Reports from the Congressional Research Service describes Russia's doctrine, forces, and modernization of nuclear weapons. Currently, Russia deploys more than 1,500 warheads on missiles and bombers capable of reaching U.S. territory. Russia's doctrine has developed into an "escalate to de-escalate" strategy, forcing an early withdrawal by adversary nations in future conflicts. Russia's Strategic Rocket Forces (SRF) is a separate branch of the Russian armed forces, comprised of three missile armies, eleven missile divisions, and approximately 60,000 personnel (Woolf 2019, 13-17).

Russia is currently developing its arsenal of ICBMs, including the SS-27 Mod 1 (Topol-M), the SS-27 Mod 2 (Yars), and the Sarmat (SS-X-30). Their Strategic Naval Forces contain ten strategic submarines of three variants: Delta, Typhoon, and Borei class. The Delta-class submarines are capable of carrying the SS-N-18 and SS-N-23 BMs, while the Borei-class is equipped with the SS-N-32 BM (Woolf 2019, 14-15).

Russia perceives the U.S. withdrawal from the ABM Treaty in 2002 and focus on homeland nuclear defense systems as destabilizing the nuclear strategy of deterrence, arguing a global BMDS will negate all other nuclear powers. Russian President Vladimir Putan stated, "We would have to improve our modern strike systems to protect our security…Russia has developed, and works continuously to perfect, highly effective but modestly priced systems to overcome missile defense." (Woolf 2019, 20)

Articles

Articles from MIT Press, the Nuclear Notebook, and the Center for Strategic & International Studies (CSIS) details China's BM programs, technologies, strategies, and goals. According to Nuclear Notebook, China continues to develop ICBM potential by modernizing a road-mobile launcher for existing ICBMs, as well as air-launched dual-capable BMs. China's policy for nuclear weapons has been "A pledge to not use nuclear weapons first, not to use nuclear weapons against non-nuclear countries or in nuclear-weapon-free zones, and to maintain only a minimum deterrent designed to ensure a survivable second-strike capability" (Kristensen & Norris 2018, 289-295). China retains approximately 120-130 land-based and 48 sea-based BMs able to deliver 280 nuclear warheads. Advanced missile capabilities include the Multiple Independently Targetable Reentry Vehicles (MIRVs), designed to penetrate U.S. missile defenses (Kristensen & Norris 2018, 289-295).

China's PLA Rocket Force and PLA Strategic Support Force control all land-based BM forces and all strategic missiles. The National Air and Space Intelligence Center (NASIC) reports that "China continues to have the most active and diverse BM development program in the world" (Kristensen & Norris 2018, 289-295). China presently operates four Jin-class submarines capable of employing BMs. Each nuclear-powered submarine can carry up to twelve JL-2s (CSS-N-14) SLBMs with a range of over 7,000 km, enough to target Hawaii from waters near China (Kristensen & Norris 2018, 289-295).

Russia continues its military expansion by upgrading is strategic nuclear arsenal, investing approximately $28 billion by 2020. The ground-based, MIRV capable ICBMs, include the SS-18, SS-19s, and SS-25s. The Russian navy maintains a fleet of ten nuclear triad SSBNs, capable of BM employment against the U.S. (U.S. Defense Intelligence Agency 2017, 29-30).

North Korea's enduring commitment to its BM and nuclear programs are steadily increasing despite an ongoing economic decline since the late 1980s. KPA Supreme Command declared that North Korea's expanding BM capabilities are not only able to conduct missile strikes throughout East Asia, but "also reach the U.S. mainland and in the Pacific forces operational region, including Guam and Hawaii." (Jane's 2019, 145)

North Korea's recent focus appears to be developing the technology to defeat or degrade the U.S. BMD systems. In 2016, missile tests achieved higher altitudes coupled with shorter ranges, inducing a steeper angle on re-entry, and faster airspeeds to defeat possible missile defenses. In 2017, North Korea demonstrated the capability to launch multiple missiles in minimal time, proving that a salvo attack is feasible (Hildreth and Kikitin 2018, 1-4). North Korea possesses two main BMs that can travel over 10,000 km, the Hwasong-14, and the Hwansong-15 (MDP 2018a). North Korea is also experimenting with SLBMs to counter the THAAD missile defense by launching at sea, outside of the MD radar field of view (Hildreth and Kikitin 2018, 1-4). These employment tactics and technological advances will create challenging problems for the GMD, Patriot, Aegis, and THAAD BMD systems.

The Ground-based Midcourse Defense (GMD) system, designed to defend the U.S. against a BM attack incorporates deployed ground-based interceptors (GBIs) from two locations. The 49th Missile Defense Battalion at Fort Greely, Alaska, maintains forty GBIs. The 100th Missile Defense Brigade at Colorado Springs, Colorado, controls the remaining four GBIs stationed at Vandenberg Air Force Base, California (MDA 2014). The GMD system utilizes numerous sensors and interceptors located throughout the world.

GBIs are silo-launched missiles designed to intercept BMs in their midcourse phase, still outside of the atmosphere and at their highest trajectory (MDA 2016). The GBI utilizes a hit-to-kill technology, relying on a multi-stage rocket booster and a kinetic kill vehicle to destroy BM warheads. The current system does not incorporate the Multiple Kill Vehicle (MKV), previously canceled in 2009 due to funding (MDA 2016). Due to this limitation, a single kill vehicle is unable to counter salvos of BMs or MIRVs. From 1997 to 2018, there have been seventeen GBI tests involving the launch of a GBI and a target missile, resulting in only nine successful intercept attempts (Williams, Karako, & Rumbaugh 2018, xxii).

Upgraded Early Warning Radars (UEWRs) are UHF phased array radars that provide early detection, tracking, and classification of BMs. The U.S. operates three UEWR sites located at Beale AFB, California, the United Kingdom, and Thule AFB in Greenland (Williams, Karako, and Rumbaugh 2018, 89). The 7th Space Warning Squadron at Beale controls the UEWR system responsible for the pacific. The radar covers a range of 3,000 nautical miles within a 240-degree sweep. Within sixty seconds of a BM launch, the on-duty crew validates and employs the necessary BMD interceptors to destroy the threat (7th Space Warning Squadron 2016).

The 13th Space Warning Squadron detachment, located at Clear Air Station, Alaska, provides early warning of ICBMs utilizing the AN/FPS-123 Solid State Phased Array Radar System (SSPARS). The SSPARS has an operational range of 3,000 nm covering a 240-degree area. The 13th SWS also operates the AN/FPS-108 Phased Array Radar (COBRA DANE), located at Eareckson Air Station on Shemya Island, AK. Cobra Dane is an L-band radar capable of detecting BMs at 2,000 miles and provides tracking and classification data within a 136-degree field of view (13th Space Warning Squadron 2018).

The Sea-Based X-Band (SBX) radar operates out of Honolulu and has a range of 2,500 miles, but only a 25-degree field of view. The SBX's design, provides long-range precision tracking, discrimination from decoys, and provides in-flight updates to GBIs. The SBX must sail from the port to the western Pacific for optimal positioning for BMD. Due to its size and weight, the SBX travels at only eight knots per hour (Williams 2018b).

THAAD systems utilize the AN/TPY-2 high resolution, X-band radars in either a terminal or forward-based mode. Currently, the U.S. controls ten TPY-2 radars, five radars assigned to THAAD units, and the others deployed to Japan (two radars), Turkey, Israel, and the Persian Gulf. Designed for BM engagement, the THAAD system can intercept BMs outside the atmosphere and upon reentry. TPY-2 radars can detect and track missiles in boost and early midcourse phases, identifying the speed and trajectories of BMs (U.S. DoD 2018a). The two sites located in Japan are located at Kyogamisaki and Shariki, have a radar detection range of 1,000 km, and an engagement range of 200 km (Williams, Karako, & Rumbaugh 2018, 85).

Currently deployed in eight countries, the Patriot missile defense system provides regional security against BMs, including Japan and South Korea. The system utilizes an AN/MPQ-65 radar, providing a 120-degree coverage with detection capability in high clutter environments. Future upgrades will include a Gallium Nitride-based Active Electronically Scanned Array radar, capable of 360-degree coverage (U.S. DoD 2016c). The radar utilizes the C-band spectrum and has an operational range of 100 km (Missile Defense Advocacy Alliance 2020a).

Deployed on eighty-four U.S. naval vessels throughout the world, the Navy supports BMD by employing the Aegis system aboard sixty-two Arleigh Burke-class Guided Missile Destroyers (DDG) and twenty-two Ticonderoga-class Cruisers (CG). The Aegis system utilizes the SPY-1 Radar and the Standard Missile-3 (SM-3) to intercept short and IRBMs during their midcourse phase of flight (MDA 2020). The AN/SPY-1 Radar has a 360-degree field of view and searches the S-band frequency for tracking and discrimination data on BMs. Twenty-eight of the Arleigh Burke-class DDG and five Ticonderoga-class CG employ the SPY-1 radar system (MDA 2020). The SM-3 missile's estimated maximum speed of 4.5 km/s and an operational range of up to 100-200 nm (185-370 km) (Johnson-Freese and Savelsberg 2013, see also U.S. Navy 2017). The SPY-1 radar has a projected range of 167 nm (310 km) (Missile Defense Advocacy Alliance 2020a).

The Aegis Ashore is a land-based version of the Navy's Aegis system, utilizing a SPY-1 radar and SM-3 (MDA 2016). The Pacific Missile Range Facility on Kauai, Hawaii, is home to the Aegis Ashore Missile Defense Test Complex (AAMDTC), conducting tests and evaluations in the development of the Aegis Ashore program (MDA 2020). The SM-3 was designed to intercept short-, medium-, and IRBMs, not ICBMs (Congressional Research Service [CRS] 2019, 2). Though not designed to destroy ICBMs, Pentagon officials state, "the SM-3 IIA's size, range, speed and sensor technology, the thinking suggests, will enable it to collide with and destroy enemy ICBMs toward the beginning or end of their flight through space, where they are closer to the boundary of earth's atmosphere" (CRS 2019, 5). The SM-3 will add another layer of defense to augment the current GMD system.

The GMD system relies on early detection of a BM launch to effectively engage a BM attack in its midcourse phase of flight. The Overhead Persistent Infrared (OPIR) is a family of satellite constellations managed by the U.S. Remote Sensing Systems Directorate at Los Angeles Air Force Base. Two of the four main satellite groups support the HD mission, the Defense Support Program (DSP), and the Space-based Infrared System (SBIRS) (Williams, Karako, and Rumbaugh 2018, 96).

DSPs are infrared sensing satellites controlled by the U.S. Air Force Space Command, providing BM launch warnings by detecting heat signatures created by boosting missiles (Williams, Karako, and Rumbaugh 2018, 96). DSPs orbit the Earth at approximately 22,300 miles (35,970 km) (Air Force Space Command Public Affairs Office 2015). SBIRS includes dual-sensor platforms that can scan extensive territories or focus on a single area of interest. The sensors operate independently and can perform each task simultaneously. MDA maintains two of the SBIRS within the Lower Earth Orbit, renaming it the Space Tracking and Surveillance System (STSS) (Williams, Karako, and Rumbaugh 2018, 96-97).

The STSS is an experimental system designed to provide persistent sensor coverage of launch to destruction of BMs (Williams, Karako, and Rumbaugh 2018, 97). The STSS orbits at 1350 km, 58-degree inclination, and has an orbital period of 120 minutes. The sensor can detect a BM launch, track its trajectory during mid-course, and transmit targeting data to remote ground- and sea-based interceptors (MDA 2017).

The data gathered by the many radars and sensors communicate with Command and Control, Battle Management, and Communications (C2BMC) network for BMD. The C2BMC collects and processes sensor information, providing a complete picture of the missile defense battlespace to HD commanders. Specifically, PACOM will receive data from TPY-2 radars, SBX, UEWRs, Cobra Dane, and various space sensors regarding any BM launch threatening the Pacific Region (Williams, Karako, and Rumbaugh 2018, 101).

Conclusion

A thorough analysis during the literature review provides evidence that there is a lack of information regarding a direct link concerning the ability of the U.S. to protect the State of Hawaii against a potential BM attack from China, Russia, or North Korea. The research methodology addressed in the next chapter will highlight the requirement for additional research regarding the evolving threats from near-peer states and rogue nations, the current capabilities of the U.S. BMD, and conduct a comparison to determine the feasibility of protecting Hawaii against the technological advancements.

The most informative research drew from the reports and articles concerning the threat capabilities to include the operational ranges, speeds, technology, warhead payloads, and defensive countermeasures. The literature review also provided essential details of the U.S. BMD capabilities and limitations. This data is necessary to compare against potential attacks to assess the effectiveness of America's BMDS.

The greatest challenge to overcome in this research concerned the classification, validity, and currency of available data. The abundance of information from web resources required additional research and validation to ensure accuracy and up-to-date facts during calculations. Trusted sources, such as Jane’s, were utilized, however, restricting the analysis to the unclassified level leads to assumptions that nations and states report accurate capabilities and limitations to the world.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

This research methodology will address the primary and secondary questions posed in Chapter One by utilizing the Joint Capabilities Integration Development System (JCIDS) process. Through a thorough examination using a Capabilities Based Assessment (CBA), the research will focus on homeland security, current threat assessments, existing capabilities for BMD, and further recommendations for study. The research will examine the following content: doctrine, organization, training, materiel, leadership, personnel, and facilities to determine any present gaps in the HD of Hawaii.

Methodology

The first step in this methodology is determining the requirement for Hawaii's HD. A review of the strategic guidance provided by the NSS, National Defense Strategy, DoD Directives, and service publications will provide the roles, responsibilities, and requirements for establishing and maintaining an effective BMD. The research will identify areas of responsibility, command structures, and service requirements to ensure successful deterrence, disruption, or destruction of BM attacks.

The next step is a thorough examination of the BM threat capabilities that China, Russia, and North Korea possess. An analysis of country-specific strategic postures and political goals will identify willingness to employ BMs against America. Evaluations of BM threat capabilities are based on deployment locations, methods of employment, and relative ranges to Hawaii. An examination of BM flight profiles, speeds, tracking, ranges, anti-jamming, signatures, quantities, and launch mechanisms will identify potential mitigation measures. After ascertaining the potential risks posed by BM threats, gaps will be identified through a detailed assessment of homeland BMDS capabilities.

An effective BMD requires the ability to employ active and passive defensive measures. Should deterrence fail, the U.S.' ability to detect, disrupt, destroy inbound missiles will result in national security. This research will identify current U.S. capabilities to detect a BM launch, track inbound missiles, C2 required from employment, and active missile defensive measures.

The early identification of BM pre- and post-launch warnings will be instrumental in defeating an attack. The research will investigate the radars, communications, and space-based capabilities that the U.S. possesses. Comparing those results with the conclusions ascertained from the threat analysis will highlight any deficiencies in those areas.

The active missile defense includes ground- and sea-based interceptors used to destroy BM attacks. The research will identify the speeds, ranges, locations, flight profiles, radars, and fire control systems of U.S. interceptor missiles and will evaluate the relative capabilities to defeat BMs. Analysis of the HD mission requirements, threat evaluations, a capabilities-based assessment, and comparing and contrasting resources will result in the identification of potential gaps in the HD of Hawaii.

Conclusion

Recognizing any limitations in the BMDS will precede further examination of potential remedies or recommendations for future research. This methodology explores the JCIDS process to determine potential materiel or organizational type solutions. The implementation of this methodology examines the current ballistic capabilities of China, Russia, and North Korea and compares them to America's ability to execute BMD. The results and analysis of this study will attempt to answer the question, how does America defend Hawaii against the evolving BM threats posed by China, Russia, and North Korea?

CHAPTER 4

ANALYSIS

Introduction

Per the methodology outlined in Chapter 3, the first step of this analysis evaluates the current threats posed by China, Russia, and North Korea. A thorough assessment of threat launch locations and operational range capabilities of varying BMs in relation to Hawaii will provide a situational understanding of the specific threats in the Pacific region. Through this investigation, the research will identify the requirements necessary to execute the BMD of Hawaii effectively.

The next step in the analysis incorporates a detailed breakdown of current U.S. BMDSs, capabilities, and limitations. Utilizing the information garnered by the study, the results will identify any potential gaps in the BMDS. Disparities in the ability to employ an effective layered missile defense system, necessary to protect the homeland, will be addressed in Chapter Five: Conclusions and Recommendations.

Analysis

China's threat to Hawaii's BMD stems from three land-based BMs, the Dong Feng-5 (DF-5), the Dong Feng-31 (DF-31), and the Dong Feng-41 (DF-41). China's navy also maintains a SLBM, the Ju Lang-2 (JL-2). China has approximately ten DF-5 silo-based ICBMs capable of ranges over 13,000 km. The DF-5A employs a single 3,900 kg warhead yielding one to three MTs or is capable of dispersing multiple warheads. The DF-5B BMs can employ three to six MIRV warheads to counter BMDs and have decreased the circular error of probability (CEP) by updating the navigational control to ensure better accuracy (MDP 2018a).

China's Rocket Force controls its BM program, managing three launch brigades containing six-ten missiles deployed in underground silos. The 801st Brigade, located at Base 54, Lingbao, Henan Province, the 804th Brigade, located at 54 base, Luanchan County of Luoyang City, Henan Province, and the 803rd Brigade, located at Base 55, Jingzhou County of Huaihua City, Hunan province. The 804th is suspected of having deployed six-ten silo-based DF-5A ICBMs in Funiu Mountain. (Sino Defence 2017). During a test flight on 18 May 1980, a DF-5 launched from the Jiuquan site, flying for 29 minutes and 59 seconds, covering over 9,070 km (Brugge 2020). Given the time and distance of the test launch, the DF-5 missile was able to travel at an average of approximately 300 km/min or 14.54 mach.

The DF-31A and DF-31AG are either silo-, road-, or, rail-mobile BMs, with estimated ranges from 8,000-11,700 km. China is assessed to have eight DF-31 ICBMs capable of carrying one MT nuclear warhead each (MDP 2018a). The DF-41 is a road- and rail-mobile ICBM with an estimated range of 12,000-15,000 km, carrying a single MT warhead or up to ten MIRV twenty, ninety, and 150 kT warheads. Capable of traveling over twenty-five Mach, the missile can target the continental U.S. within thirty minutes (MDP 2018a). Experimental test flights of the DF-41 are complete, but the estimated operational date or production numbers are still unknown (Kristensen & Norris 2018, 289-295).

China also fields the Ju Lang-2 (JL-2) intercontinental-range, SLBM. JL-2s can launch from one of four Jin-class nuclear submarines, each armed with twelve JL-2

SLBMs. The SLBMs range from 8,000-9,000 km, employing one MT nuclear warhead or three to eight MIRVs with twenty, ninety, or 150 kT warheads (MDP 2018a). Due to the location of China's land-based BMs sites, the capability to employ mobile ICBMs and the ability to maneuver nuclear-equipped submarines in range threatens the HD of Hawaii.

Utilizing the most dangerous course of action (COA), a DF-41 road-mobile system deploying in the vicinity of (IVO) the 406th Brigade in Tonghua, China, an ICBM traveling 4,500 nm at twenty-five Mach will reach Honolulu, Hawaii in approximately fifteen minutes. A DF-41 BM carrying ten MIRVs each equipped with a 150 kT warhead can simultaneously target several critical infrastructures and population centers to include Honolulu, Camp Smith, JBPHH, Honolulu International Airport, Wheeler Army Air Base, Kalaeloa airfield, Kaneohe Marine Corps Base, and the Hawaii Air National Guard Headquarters at Diamondhead.

Utilizing Nukemap, a nuclear destruction calculator developed by Alex Wellerstein, historian of science at the Stevens Institute of Technology, the estimated casualties will surpass 800,000 (see Figure 1). The strike will destroy multiple key infrastructures and missile defense nodes rendering Hawaii defenseless against future attacks and unable to project combat power to increase operational ranges.

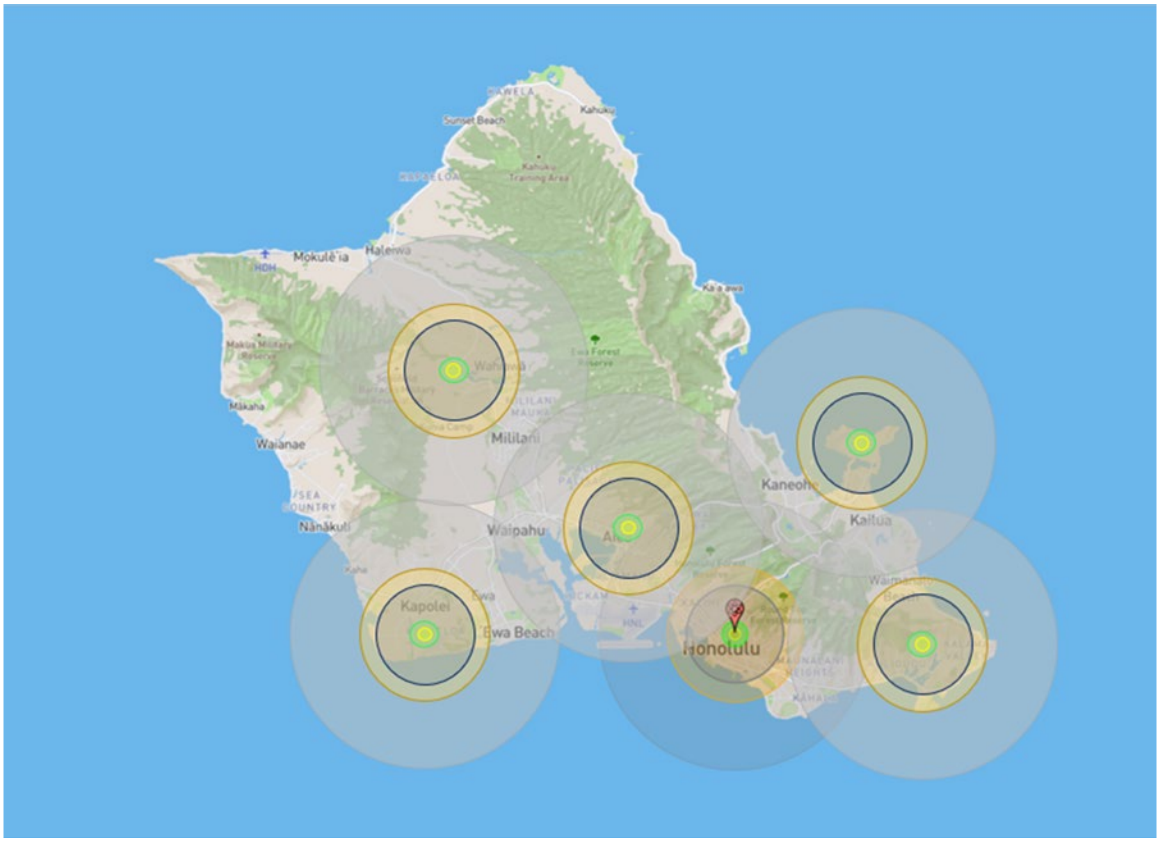

Figure 1. Estimated Blast Rings of Six MIRV 150kT Nuclear Warheads

Source: Wellerstein 2020.

China is also capable of launching a DF-5 BM in vicinity of (IVO) Tonghua that will travel at approximately 14.54 Mach, reaching Hawaii within twenty-five minutes. The missile can employ a single three MT nuclear warhead via an airburst or surface detonation resulting in an estimated 609,890 casualties (See Figure 2). The results achieved for both nuclear simulations were based on an average of 901,610 people in the blast ranges of the detonations (Wellerstein 2012). Similarly, Russia poses a significant threat to the safety of America's homeland.

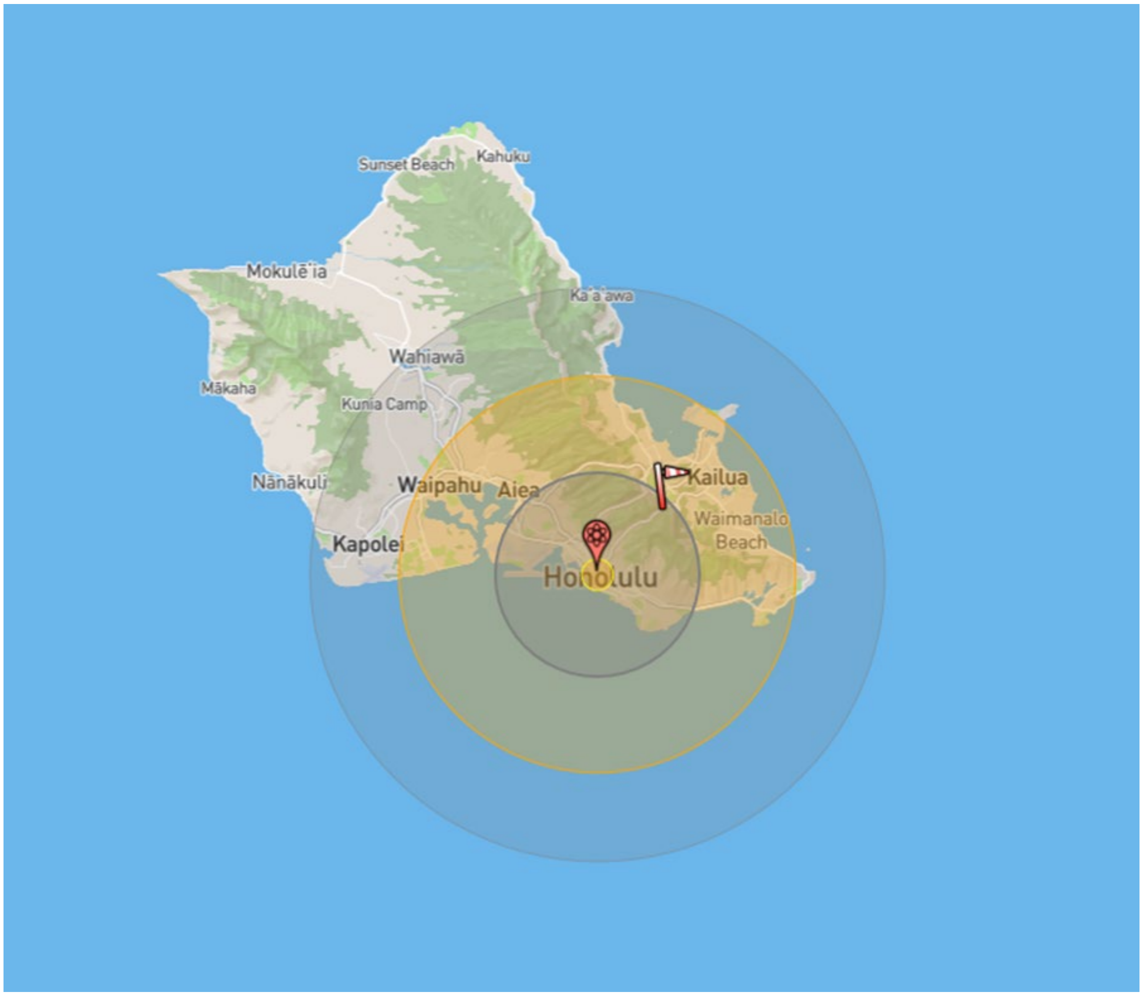

Figure 2. Estimated Blast Ring of One MT Nuclear Warhead

Source: Wellerstein 2020.

Russia threatens the security of Hawaii by four different models of land-based ICBMs and two variants of SLBMs. The four types of land-based ICBMs are the SS-18 “Satan,” SS-19 “Stilleto,” SS-25 “Sickle,” and SS-27 “Sickle-B.” The SS-18 ICBM ranges 11,000 km and can employ ten MIRVs with a 500-750 kT yield for each warhead. Russia possesses forty-six operational SS-18 ICBMs, projected to upgrade to the Sarmat missile (MDP 2018c). The SS-19 ICBM is capable of ranges up to 10,000 km, carrying up to six MIRVs, and a payload of 500 kT each (MDP 2018c). The SS-25 ICBM is road-mobile missile capable of ranges up to 10,500-11,000 km, carrying a 550-800 kT nuclear warhead, and equipped with ninety operational launchers (MDP 2018c). The SS-27 ICBM has a range of 11,000 km, is road-mobile or silo-based, and carries a single 500 kT warhead. Current assessments predict eighteen road-mobile launchers and sixty or more silo-based facilities (MDP 2018c).

The SS-N-18 "Stingray" SLBM with a range of 6,500 km, carries a 200 kT Nuclear warhead, and up to three MIRVs. The Russian navy possesses thirty-two SS-N-18 SLBMs on two Delta III submarines (MDP 2018c). The SS-N-23 "Skiff" SLBM deployed on Delta IV nuclear submarines are capable of up to 8,300 km and employs MIRV technology with 100 kT warheads. Russia is estimated to have six Delta IV submarines, each capable of carrying 16 SS-N-18 SLBMs for a total of ninety-six SLBMs in their inventory (MDP 2018c).

Analyzing the most dangerous COA, Nukemap calculations assumed an SS-18 BM configured with ten MIRVs, each containing a 750 kT warhead. The results estimated over 900,000 casualties and the destruction of crucial infrastructures necessary to conduct ongoing defensive measures or a counterattack (Wellerstein 2012) (See Figure 3). The Russian BM will be able to target numerous key locations, including the city of Honolulu, JBPHH, Kaneohe Marine Corps base, USINDOPACOM headquarters at Camp Smith, and Wheeler Army Airfield. The massive loss of life and defensive capabilities renders the state ineffective in producing sufficient combat power, resulting in the loss of a strategic location for future warfare. In addition to near-peer threat countries, rogue states pose significant threats to the safety and security of Hawaii.

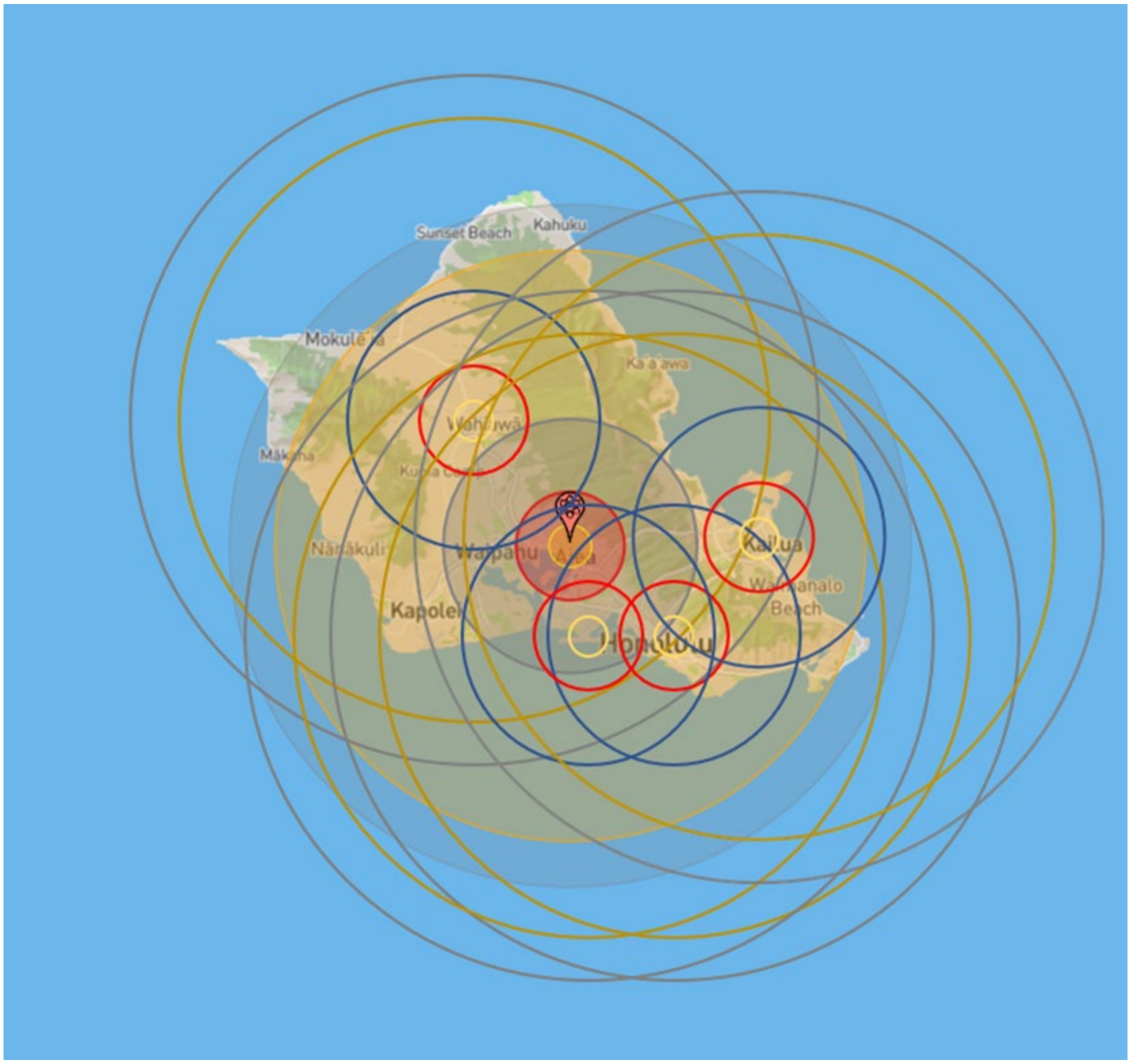

Figure 3. Estimated Blast Rings of Five 750 kT Nuclear Warheads

Source: Wellerstein 2020.

North Korea is continuously investing in BM technology that threatens the U.S. and possesses two land-based BMs that are within range of Hawaii. The Hwasong-14 is a road-mobile launcher and has a range of 10,000 km (MDP 2018b). The Hwasong-15 is a road-mobile BM and has a range of 8,500-13,000 km. Both BMs are nuclear-capable and pose significant threats to Hawaii. On 29 Nov 2017, North Korea flight-tested the Hwasong-15, flying 53 minutes and traveling 950km, and reaching an apogee of 4,475 km. Analytical assessments extrapolated from the test data projects that the BM can travel over 13,000 km (MDP 2018b).

Though the North Korean BMs are not as advanced, nor carry the destructive capabilities compared with China and Russia, they can still cause severe damage to the State. According to the Nukemap calculator, a North Korean BM carrying a 150 kT warhead detonated over Honolulu will achieve an estimated 307,180 casualties (See Figure 4) (Wellerstein 2012). However, due to the technological limitations of North Korean BMs, they are only capable of employing a single warhead. North Korea’s BM technology lacks the MIRV weapon system, making them highly susceptible to the current BMDS.

Figure 4. Blast Range Rings for 150 kT Nuclear Warhead

Source: Wellerstein 2020.

The analysis demonstrates China, Russia, and North Korea all possess the capability to employ a BM able to target Hawaii. Next, a thorough examination of the U.S.' defensive capacity to identify, track, target, engage, and defeat inbound BM attacks will evaluate the effectiveness of the BMDS. Ground-based Missile Defense incorporates numerous radars, sensors, and communication links required to preserve HD. The first step in BMD is the notification of a BM launch detected by space-based sensors.

Space-based sensors will identify a BM launch by detecting the heat signature created by the missile's boost phase. The two operational systems are currently the Defense Support Program (DSP) and the Space-based Infrared System (SBIRS). The STSS, still in the testing and evaluation phase, can also provide early warning detection of a BM launch. DSP satellites maintain a geosynchronous orbit at approximately 22,300 miles (35,970 km), providing a persistent early warning capability. The infrared sensors rely on heat signatures and are not dynamically taskable to track and discriminate BMs (Williams 2016). SBIRS will replace the DSP satellites providing enhanced detection and tracking capabilities.

The SBIRS can identify activity over wide territories and focus on areas of interest to detect lower heat signatures than the DSP. SBIRS consists of two Highly Elliptical Orbit (HEO) sensors on host satellites and four GEO satellites. The GEO satellite scanning sensor provides 24/7 global strategic missile warning capability (Air Force 2017). The HEO scanning sensor, located in the Molniya orbit, will provide ICBM observation and surveillance (Air Force Technology 2020). The system's design detects launches, provides missile types, burnout velocities, trajectories, and points of impact (MDA 2017). Though upgraded from the older DSP, SBIRS cannot provide the detailed discrimination required to separate warheads from decoys. Due to the lack of discrimination data, cueing other sensors and missile defense systems are critical for successful interceptor employment.

The STSS is an experimental system with plans to purchase additional satellites or upgrading to the Precision Tracking Space System (PTSS). The STSS consists of two Lower Earth Orbit satellites designed to track BMs in all phases of flight providing discrimination of warheads from decoys. The STSS orbits the earth at approximately 1,350 km at a 58-degree inclination and 120-minute orbital period (MDA 2017). Due to the limited amount of satellites and its low orbit, the satellites have line-of-sight limitations and must rely on datalink capabilities and other sensors to provides cueing for gaps in coverage. Based on the three types of space-based sensors, the U.S. will be able to detect a global BM launch immediately but requires the assistance of terrestrial-based radars and sensors to provide the essential targeting and discrimination capabilities necessary for a successful engagement.

Effective BMD includes the incorporation of ground-based sensors. A thorough analysis of the UEWRs, SPY-1D, TPY-2, Cobra Dane, and the Sea-based X-band Radar (SBX) will assess their capabilities to provide the required targeting and discrimination data necessary for interceptor engagements. The UEWR, located at Beale Air Force Base in California, has a detection range of 3,000 nm and 240-degree coverage. Beale is approximately 2,483 miles away from Hawaii, providing coverage for only the last 500 miles of flight time. The most capable threat, a DF-41 BM traveling at twenty-five Mach, will be in range less than a few minutes, providing limited tracking and discrimination data. The UEWR radar located at Clear Air Station, Alaska, also provides 3,000 miles of radar coverage and a 240-degree field of view. The location of the airbase in relation to Hawaii is approximately 3,030 miles away, just outside of the radar's operational range. Due to the ranges and locations of the UEWR systems, limited tracking is available during a BM attack against Hawaii. The system must rely on other sensors to fill the coverage gaps.

The Cobra Dane radar, located on the island of Shemya, Alaska maintains a sensor range of 2,000 nm and a 136-degree field of view. The island is located approximately 2,663 miles (4,287 km) from Hawaii, outside of the effective limits of the radar system. However, due to the proximity of Shemya Island to China, Russia, and North Korea, the Cobra Dane Radar will have limited tracking capabilities during the mid-phase time of flight. The radar will provide tracking data and accurate classification information enhancing cueing capabilities for other systems. Due to system limitations, distance, and location in relation to Hawaii, BMs will exceed the range and field of view of the system during the terminal phase of flight.

Forward-based TPY-2 radars located at Shariki and Kyogamisaki, Japan, provide an operational radar range of 621 miles (1,000 km) with 360-degree coverage. The TPY-2 radars can provide detection and tracking information of BMs in the early and mid-course phases, calculating speeds and trajectories. The system ranges will only provide early data on missiles launched from China or North Korea due to the proximity of the radar sites. A BM traveling at twenty-five Mach will exceed the range of the TPY-2 radar within a few minutes, providing a gap in coverage till another BMD sensor acquires the missile.

The Sea-based X-band Radar (SBX) radar provides detailed tracking and discrimination information up to 2,500 miles and a 26-degree field of view. The radar is not a stand-alone system and requires queuing from other sensors to adjust viewing angles to detect and track a BM accurately. Another limitation of the radar system pertains to its mobility. To achieve optimal positioning from its port in Hawaii to the

Western Pacific, the SBX may take up to nine days to travel 2,000 miles traveling at eight knots/hr.

Aegis systems equipped with the SPY-1 radar are aboard thirty-four Navy BMD ships offering another layer of detection, tracking, and discrimination data. The SPY-1 radars utilize S-band frequencies and have an operational range of 167 miles (310 km) with 360-degree coverage. Due to their limited ranges, Aegis-equipped ships require pre-positioning to ensure adequate BMD. The SPY-1 radar is also a feature of the Aegis Ashore program located on Kauai, Hawaii. The Kauai site is currently a testing and evaluation site and not fully integrated into the operational BMDS. Due to the limited ranges of the SPY-1 radar systems, prior tracking provides essential data to the Aegis interceptors to ensure effective targeting during BMD.

In addition to the test site at Kauai, Kwajalein Atoll houses the Ground-based Radar Prototype (GBR-P) radar providing 1,243 miles (2,000 km) range and 360-degree coverage, but is currently employed as a test and evaluation facility. Kwajalein Atoll is located approximately 2,300 miles (3,675 km) to the Southwest of Hawaii, and if activated, could provide limited mid-course tracking coverage of a BM launched out of southern China. (See Figure 5).

A thorough analysis of the available radars and sensors providing the necessary early warning, launch indications, tracking, identification, targeting, and discrimination data for an effective BMD uncovers several gaps in coverage. The results indicate that an immediate detection of a BM launch from China, Russia, or North Korea is feasible. The tracking and discrimination data required for successful missile defense against evolving BM threats reveal several gaps in radar coverages due to limited ranges, locations, and capabilities of available assets. The BMD terrestrial sensors do not provide "birth-to-death" BM tracking and discrimination data required for Hawaii's defense.

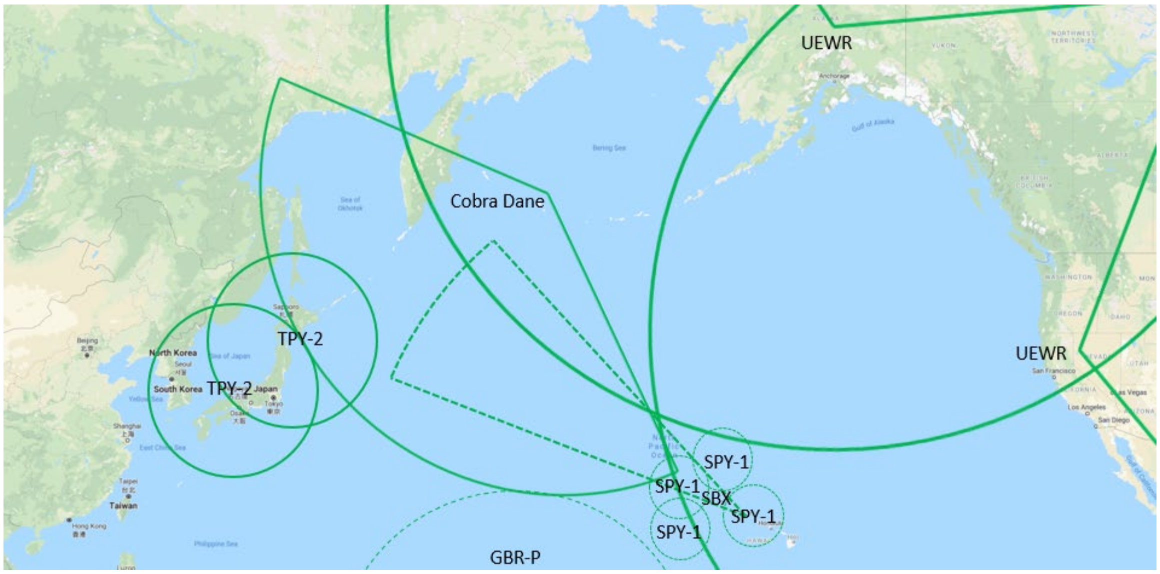

Figure 5. U.S. BMD Terrestrial-based Sensor Coverages

Source: Created by author using PowerPoint and Google Maps.

The C2BMC network program collects and processes the data obtained by space-, land-, and sea-based sensors to provide a common operating picture of the missile defense battlespace. The information compiled provides the necessary intelligence to execute an effective BMD. Communicating with launch platforms, the provides cueing and discrimination data required for an effective engagement utilizing a hit-to-kill interceptor. The current launch platforms for interceptor missiles consist of the Aegis system SM-3, THAAD, and Ground-based interceptors.

Deployed Aegis SM-3 missiles on thirty-three Arleigh Burke-class Guided Missile Destroyers (DDG) and three Ticonderoga-class cruisers (CG) are available to assist in the HD mission (Naval Technology 2020). Arleigh Burke-class destroyers achieve speeds up to thirty knots (U.S. Navy 2020b). SM-3 missiles have a maximum speed of 4.5 km/s and can range out to 100-200 nm (185-370 km) (Johnson-Freese & Savelsberg 2013). Pearl Harbor, Hawaii is the home port for nine destroyers, the USS Michael Murphy DDG-112, USS Halsey DDG-97, USS Chung-Hoon DDG-93, USS Chafee DDG-90, USS John Paul Jones DDG-53, USS Preble DDG-88, USS Hopper DDG-70, USS William P. Lawrence DDG-110, and USS Wayne E. Meyer DDG-108. Pearl Harbor is also home to a single guided-missile cruiser, The USS Port Royal (CG 73). The Aegis-equipped cruiser travels up to thirty knots and is BMD capable (U.S. Navy 2017b).

Several limitations for the employment of surface ships include missile employment ranges, limited Aegis-equipped vessels, and competing operational missions. The original design of the Aegis system and SM-3 missiles were to intercept the midcourse and terminal phases for short and medium-range BMs, not ICBMs. The SPY-1 radar requires advance warning from other sensors to enable tracking and discrimination (Williams, Karako, and Rumbaugh 2018, 94). Due to the speeds of BMs, up to twenty-five Mach, and the speeds of destroyers and cruisers, up to thirty knots, the surface ships must be in a defensive position before a BM launch. Ship locations are essential due to the limited employment ranges of 100-200 nm and must be pre-positioned to defend Hawaii against a BM attack. The high demand, low-density assets lead to competition for these valuable resources throughout the INDOPACOM AOR.

The Aegis Ashore program currently operates on Kauai, Hawaii, in the Pacific region. The site is for testing and evaluation only and not linked to the operational BMD program. The defense of Hawaii will depend on the proper positioning of surface ships equipped with Aegis to counter a BM attack effectively. In addition to Aegis, the Terminal High Altitude Area Defense (THAAD) system also provides a layer of BMD.

The THAAD system utilizes hit-to-kill technology during the terminal phase of flight within an employment range of 200 km (Williams, Karako, and Rumbaugh 2018, 85). The system is deployed with seven batteries throughout the U.S., Guam, and South Korea. There are currently no THAAD batteries located in Hawaii. Due to the limited ranges and locations of the system, the present sites will not provide an intercept option during a BM attack against Hawaii. Similarly, to the THAAD, the Patriot missile defense system provides regional security against BMs.

Deployed Patriot systems are in eight countries throughout the world, including Japan and South Korea, but currently not in Hawaii. The defense system provides a 360-degree field of view out to 100 km (Missile Defense Advocacy Alliance 2020). Due to the proximity and range of the Patriot deployed locations, the system will not provide effective defensive capabilities for the protection of Hawaii. The remaining kinetic option and primary BMD interceptors are the Ground-based Interceptors (GBIs).

GBIs are located at two locations in the U.S., Fort Greely, Alaska, and Vandenberg Air Force Base (AFB), California. Fort Greely maintains forty GBIs and is located approximately 3,000 miles to the north of Hawaii. The GBIs has an estimated closing speed of 25,700 km/h (16,000 mph), which will reach Hawaii within eleven and a half minutes (Parsch 2007). Taking the worst-case scenario of a BM traveling at twenty-five Mach launched from 4,500 miles and assuming an immediate boost detection followed by an interceptor engagement decision within sixty seconds, the interceptor will destroy a BM approximately 400 miles from Hawaii with less than two minutes time till impact. Though the numbers prove a successful defense is possible, past evaluations have uncovered potential failures.

Numerous test failures occurred during the evolution of GBIs stemming from three successive intercept failures in 2010 and 2013. Of seventeen intercept tests since 1991, only nine interceptors have successfully destroyed their targets. A significant concern highlighted the lack of communication data between sensors and the Exo-atmospheric Kill Vehicle (EKV) (Williams, Karako, and Rumbaugh 2018, XVI to XXII). Along with the mediocre results from past intercept evaluations, threat countries continue to expand their BM capabilities to include Multiple Independent Reentry Vehicles (MIRVs).

GBIs employ 1980s technology utilizing a hit-to-kill vehicle limiting the interceptor to engage only one target. China and Russia both have developed BMs that employ up to ten MIRVs, each capable of carrying a nuclear warhead. The evolving technology overwhelms BMDs while targeting multiple key locations. Due to the limited time restraints, the number of interceptors, and reduced discrimination data from available sensors, the GBIs will not be able to defend Hawaii against a BM attack utilizing MIRV technology effectively.

Vandenburg AFB supports four GBIs and is located approximately 2,430 miles to the east of Hawaii. Based on the same flight characteristics and launch response, a GBI from Vandenburg will impact a single BM at approximately thirteen minutes from launch, destroying the missile 700 miles before Honolulu with two and a half minutes of flight remaining. These calculations were based on the same assumptions of a BM traveling at twenty-five Mach for 4,500 km. The GBIs from Vandenburg AFB have the same limitations as Fort Greely and will only be able to engage a single warhead with each EKV. The GMD system has demonstrated marginal capabilities against a single BM during evaluations and does not have the capability to target multiple salvos of warheads or MIRVs.

Conclusion

The thorough analysis conducted through a capabilities-based assessment, examined the evolving BM threats posed by China, Russia, and North Korea. Comparing the threat evaluation against the current missile defense systems fielded by the U.S. charged with maintaining the HD of Hawaii yielded several results. The research has proven numerous gaps in sensor coverages, limited low-density assets, and technological disparities necessary to execute an effective global missile defense of the nation.

The inadequate coverage of space-, ground-, and sea-based sensors do not provide the tracking and discrimination data required for birth-to-death information of adversary BMs. The detailed information necessary for the identification of decoys and targeting multiple kill vehicles are not available during the BMs' entire anticipated trajectory. The NSS calls for a layered BM defense system, however, high-demand, low-density availability of Aegis-equipped surface vessels plague the Pacific. Pre-positioning naval ships to execute 24/7 defense of Hawaii will draw crucial resources from competing operational needs.

Evolving technological advances in China, Russia, and North Korea continue to challenge America's BMD system. The incorporation of longer ranges, higher altitudes, faster speeds, multiple warheads, and decoys will overwhelm current defensive capabilities. U.S. interceptors still rely on hit-to-kill technology and can only engage a single warhead with each interceptor missile.

The U.S. BMD system maintains marginal capability to defend Hawaii against a BM equipped with a single warhead from China, Russia, or North Korea. However, an advanced ICBM traveling at speeds of twenty-five Mach, employing decoys, and MIRVs weapon technology, will overwhelm the missile defense systems and render Hawaii vulnerable. America's BMD system requires improvements in sensor coverages and interceptor capabilities to achieve an adequate layered missile defense system.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

> He who defends everything defends nothing.
>
> —Frederick the Great, BrainyQuote 2020

A comprehensive literature review highlighted the significance of America's safety and security by examining several key government strategic documents, policies, and guidelines. The NSS lists HD as one of its top priorities, calling for a layered missile defense system. A capabilities-based assessment substantiated the evolving BM technology possessed by China, Russia, and North Korea comparing them to existing U.S. BMDS. The results identified gaps in sensor coverages, insufficient tracking and discrimination data, and disparities in kill vehicle technologies. USINDOPACOM recognizes the advancing threat in the Pacific region, requesting budgetary needs to increase critical munitions, enhance BMD capabilities, and expand space-based sensor coverages and technology (Davidson 2019, 1).

Utilizing the Joint Capabilities Integration and Development System (JCIDS) process identifies the acquisition requirements and procurement of future defensive capabilities. The U.S. must acquire sensors that can provide the necessary scope and range of the entire Pacific region to provide adequate targeting and discrimination data for an effective BMD. Further research and development of space-based sensors that can provide a greater level of fidelity and tracking of multiple missiles are essential in distinguishing warheads from debris and decoys.

Operationalizing the current STSS and increasing the number of satellites will result in greater discrimination capabilities and decreased sensor gaps throughout the Pacific region due to line-of-sight limitations. The proposed upgrade to the STSS, the Precision Tracking Space System (PTSS), or similar systems would provide persistent global coverage and a birth-to-death tracking and discrimination capability to the BMDS. Terrestrial-based radars and sensors will provide an additional level of protection in the Pacific.

The Patriot Advanced Capability (PAC-3) and Terminal High Altitude Area Defense (THAAD) missile defense systems have also shown capabilities against BMs during terminal phases of flight. Designed for regional defense, both systems target short- and medium-range BMs. ICBM defensive capabilities requires further research and testing. Hawaii currently does not possess any PAC-3 or THAAD BMD systems.

Aegis systems are either sea- or land-based and located throughout the Pacific region. The Aegis systems employed by the U.S. Navy, have limited ranges and competing operational requirements to include maritime security. Relocating or surging Aegis BMD-capable ships armed with the SM-3 Blk IIA interceptors and positioning them to defend Hawaii against BM threats will provide another layer of defense (DoD 2019, XIII). Though the sea-based assets can provide added security based on deployments and locations of ships, another alternative is to operationalize the Aegis Ashore Missile Defense Test Center in Kauai, Hawaii. The Aegis Ashore test site will aid in strengthening the defense of Hawaii against BM attacks (U.S. DoD 2019, XIII). In addition to Aegis, bolstering the capability to engage multiple warheads simultaneously will also improve BMDs.

Currently, all U.S. BM interceptors utilize a hit-to-kill technology which requires precise guidance, detailed discrimination data, and can only target a single warhead. China and Russia sustain BMs capable of employing multiple independently targetable reentry vehicles (MIRVs) that will overwhelm BMDS. The U.S. requires upgraded kill vehicle technology to defeat the evolving MIRV weapons to defend the homeland effectively against a BM attack.

Proposed recommendations range from acquiring a redesigned kill vehicle (RKV), a multi-object kill vehicle (MOKV), and directed energy. The RKV increases performance and reliability, improved data communications, increasing the interceptors' probability of kill. The MOKV will achieve a volume kill by destroying numerous targets within a threat cloud, reducing the amount of interceptors required and the ability to counter the MIRV threat (Williams, Karako, and Rumbaugh 2018, 79-80). Alternatively, directed energy offers another possible solution to countering the evolving BM threat.

The concept of directed energy utilizing Unmanned Aerial Vehicle (UAV) mounted lasers, flying at 65,000 feet, will provide an alternative layer to BM defense (Williams, Karako, and Rumbaugh 2018, 112-113). Directed energy programs currently include the Air Force's Demonstrator Laser Weapons System (DLWS), the Army's High Energy Laser-Mobile Demonstrator (HEL-MD), and the Navy's Laser Weapon System (LAWS). However, further research and testing is required to verify the applicability towards engaging ICBMs. Directed energy prototypes also have several limitations, including trade-offs between range, power, and altitude. A UAV-borne laser will need to get close enough to destroy a BM, requiring a great deal of power to engage targets at standoff ranges (Williams, Karako, and Rumbaugh 2018, 112-113).

Conclusion

The current BMDS has insufficient capabilities to defend Hawaii against the evolving BM threat posed by China, Russia, and North Korea. The present technology of near-peer threats can overwhelm the defensive resources protecting the Pacific region. The U.S. must rely on deterrence from aggression through diplomacy to preserve the safety and security of Hawaii. In order to fulfill the NSSs objective of creating an effective layered missile defense system, significant investments for developing enhanced sensors and radars, upgrading kill vehicles and interceptors, and relocating defensive systems in proximity to the state must be a priority. Numerous upgrades to potential adversary's BM technology are constantly under development and require further study to ensure the nations' security.

Recommendations for Further Study

Further examination of the BM threats posed by China, Russia, and North Korea requires constant evaluation due to the evolving technological advances that continue to degrade the U.S.' defensive measures. China and Russia persist in testing and evaluating HGV designed to penetrate the U.S.' BMDSs. A detailed analysis ensuring successful defense against HGVs ensures adequate resources are fielded to counter the emerging technology.

Bolstering BMD capabilities will fortify homeland security, strengthen deterrence, ensure protection for allies and partners, and prepare for future threats. Research and evaluation must continue to expand the capabilities of space- and terrestrial-based sensors to provide the range and level of detail required for targeting advanced BM technology. In addition to sensors and radars, emphasis on explorations into new multi-target kill vehicles and directed energy is necessary to counter multiple independent reentry vehicle warheads designed to defeat the current U.S. BMDS.

For short-term success, operationalizing the Aegis Ashore test site on Hawaii and positioning Aegis destroyers provides a layered missile defense system critical in countering BM attacks. To combat the pace of evolving threats, the DoD must prioritize speed of delivery, continuous adaptation, and deliver enhanced performance by streamlining the acquisition process to ensure flexibility in developing, testing, and fielding missile defense systems (U.S. DoD 2019, XV). The persistent BM advances of China, Russia, and North Korea present an enduring threat that, if not addressed today, may prove catastrophic tomorrow.

GLOSSARY

Apogee. The farthest or highest point: culmination (Merriam-Webster Dictionary 2011).

Active AMD. The Direct defensive actions taken to destroy, nullify, or reduce the effectiveness of hostile air and BM threats against friendly forces and assets (U.S. Joint Chiefs of Staff 2017, I-16).

Aerospace defense. All defensive measures designed to destroy or nullify attacking enemy aircraft and missiles and also negate hostile space systems. An inclusive term encompassing air defense, ballistic missile defense, and space defense (U.S. Joint Chiefs of Staff 2017, GL-8).

Ballistic missile. Any missile that does not rely upon aerodynamic surfaces to produce lift and follows a ballistic trajectory when thrust is terminated (U.S. Joint Chiefs of Staff 2017, ix).

Ballistic missile defense. Defensive measures designed to destroy attacking enemy BMs, or to nullify or reduce the effectiveness of such attack (U.S. Joint Chiefs of Staff 2017, I-6).

Ballistic missile defense capabilities. BMD systems provide surveillance, detection, tracking, and lower- and upper-tier intercept capabilities to counter BMs of all ranges. The objective is an integrated, layered architecture with overlapping sensors and weapons to enable multiple engagement opportunities (U.S. Joint Chiefs of Staff 2017, V-2).

Decentralized execution. Permits timely, decisive action by tactical commanders without compromising the ability of operational-level commanders to direct operations (U.S. Joint Chiefs of Staff 2017, V-2).

Engage. Directs or authorizes units and weapon systems to fire on a designated target (U.S. Joint Chiefs of Staff 2017, V-23).

Geosynchronous. Having an orbit around the earth with a period equal to one sidereal day (Merriam-Webster 2011).

Global missile defense. Encompasses MD operations, activities, or actions that affect more than one GCC and require synchronization among the affected commands to coordinate effective allocation, deployment, and employment of capabilities necessary to deter and prevent attacks, destroy enemy missiles, or nullify or reduce the effectiveness of an attack (U.S. Joint Chiefs of Staff 2017, x).

Homeland defense. The protection of United States sovereignty, territory, domestic population, and critical infrastructure against external threats and aggression or other threats as directed by the President (U.S. Joint Chiefs of Staff 2018, GL-9).

Homeland security. A concerted national effort to prevent terrorist attacks within the United States; reduce America's vulnerability to terrorism, major disasters, and other emergencies; and minimize the damage and recover from attacks, major disasters, and other emergencies that occur (U.S. Joint Chiefs of Staff 2018, GL-9).

Integrated air and missile defense. Integration of capabilities and overlapping operations to defend the homeland and U.S. national interests, protect the joint force, and enable freedom of action by negating an enemy's ability to create adverse effects from their air and missile capabilities (U.S. Joint Chiefs of Staff 2017, x).

Layered defense. Provides multiple engagement opportunities, beginning at the maximum range from friendly forces and areas (U.S. Joint Chiefs of Staff 2017, V-2).

Molniya Orbit. A highly elliptical orbit with an inclination of 63.4 degrees, orbital period of approximately half a sidereal day, and an apogee altitude of 25,000 miles (40,000 km) (Wikipedia contributors 2020).

Passive AMD. All measures, other than active AMD, taken to minimize the effectiveness of hostile air and BM threats against friendly forces and assets. Includes detection, warning, camouflage, concealment, deception, dispersion, hardening, and the use of protective construction (U.S. Joint Chiefs of Staff 2017, I-7).

APPENDIX A

MISSILE SPEED CALCULATIONS

Ballistic missile traveling at 25 Mach 4,500 miles time to impact:

Mach: 761.20 mph

25 Mach: 761.21 mph x 25 = 19,030.25 mph

Miles per minute: 19,030.25 mph ÷ 60 min = 317.17 mi/min

Time to travel: 4,500 mi ÷ 317.17 mi/min = 14.19 min

Ground-based Interceptor traveling at 16,000 mph:

Miles per minutes: 16,000 mph ÷ 60 min = 266.67 mi/min

Time to travel 3,000 miles: 3,000 mi ÷ 266.67 mi/min = 11.25 min

Time to travel 2,430 miles: 2,430 mi ÷ 266.67 mi/min = 9.11 min

REFERENCE LIST

7th Space Warning Squadron. 2016. Beale Air Force Base. 25 May. Accessed 21 March 2020. https://www.peterson.af.mil/About/Fact-Sheets/Display/Article/326225/7th-space-warning-squadron/.

13th Space Warning Squadron. 2018. Peterson Air Force Base. 6 August. Accessed 21 March 2020. https://www.peterson.af.mil/About/Fact-Sheets/Display/Article/326223/13th-space-warning-squadron/.

Air Force. 2017. "Space Based Infrared System (SBIRS)." Los Angeles Air Force Base. 22 March. Accessed 26 March 2020. https://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/734550/space-based-infrared-system-sbirs/.

Air Force Space Command Public Affairs Office. 2015. "Defense Support Program Satellites." U.S. Air Force Fact Sheets. 23 November. Accessed 25 March 2020. https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104611/defense-support-program-satellites/.

———. 2017. "Upgraded Early Warning Radars." Air Force Space Command. 22 March. Accessed 2 March 2020. https://www.afspc.af.mil/About-Us/Fact-Sheets/Display/Article/1126401/upgraded-early-warning-radars/.

Air Force Technology. 2020. "Space Based Infrared System (SBIRS)." Accessed 26 March 2020. https://www.airforce-technology.com/projects/space-based-infrared-system-sbirs/.

Air National Guard. n.d. Wheeler Army Airfield. Accessed 1 March 2020. https://www.goang.com/locations/hawaii/wheeler-army-airfield.html.

The Associated Press. 2017. "What is an Intercontinental Ballistic Missile?" *Defense News*. 5 July. Accessed 2 March 2020. https://www.defensenews.com/space/2017/07/05/what-is-an-intercontinental-ballistic-missile/.

BrainyMedia Inc. 2020. Frederick the Great Quotes. Accessed 14 May 2020. https://www.brainyquote.com/quotes/frederick_the_great_140989.

Brugge, Norbert. n.d. "The Chinese DF-5 Missile." Accessed 31 March 2020. http://www.b14643.de/Spacerockets/Specials/DF-5/index.htm.

The Center for Arms Control and Non-Proliferation. 2017. "Multiple Independently Targetable Reentry Vehicle." Accessed 3 March 2020. https://armscontrolcenter.org/wp-content/uploads/2017/08/MIRV-Factsheet.pdf.

Center for Strategic and International Studies (CSIS). 2018a. "Aegis Ballistic Missile Defense." *Missile Threat*. June 14. Accessed 23 March 2020. https://missilethreat.csis.org/system/aegis/.

———. 2018b. "AN/SPY-1 Radar." *Missile Threat*. 11 December. Accessed 23 March 2020. https://missilethreat.csis.org/defsys/an-spy-1-radar/.

———. 2018c. "Ground-based Interceptor (GBI)." *Missile Threat*. 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/defsys/gbi/.

———. 2018d. "Missiles of North Korea." *Missile Threat.* 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/country/dprk/.

———. 2018e. "Space Tracking and Surveillance System (STSS)." *Missile Threat*. 11 August. Accessed 23 March 2020. https://missilethreat.csis.org/defsys/stss/.

———. 2018f. "Space-based Infrared System (SBIRS)." *Missile Threat*. 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/defsys/sbirs/.

———. 2018g. "SS-18 Satan." *Missile Threat.* 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/missile/ss-18/.

———. 2018h. "SS-19 Stiletto." *Missile Threat.* 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/missile/ss-19/.

———. 2018i. "SS-25 (RS-12M Topol)." *Missile Threat.* 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/missile/ss-25/.

———. 2018k. "SS-27 Sickle B (RT-2PM2 Topol-M)." *Missile Threat.* 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/missile/ss-27/.

———. 2018l. "SS-N-18 Stingray." *Missile Threat*. 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/missile/ss-n-18/.

———. 2018m. "Terminal High Altitude Area Defense (THAAD)." *Missile Threat*. 14 June. Accessed 23 March 2020. https://missilethreat.csis.org/system/thaad/.

———. 2018n. "TPY-2 X-band Radar." *Missile Threat*. 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/defsys/tpy-2/.

———. 2019a. "DF-5 (Dong Feng-5 / CSS-4)." *Missile Threat*. 18 November. Accessed 23 March 2020. https://missilethreat.csis.org/missile/df-5-ab/.

———. 2019b. "DF-31 (Dong Feng-31 / CSS-10)." *Missile Threat*. 8 October. Accessed 23 March 2020. https://missilethreat.csis.org/missile/df-31/.

———. 2019c. "DF-41 (Dong Feng-41 / CSS-X-20)." *Missile Threat*. 8 October. Accessed 23 March 2020. https://missilethreat.csis.org/missile/df-41/.

———. 2019d. "Hwasong-14 (KN-20)," *Missile Threat*. 5 November. Accessed 23 March 2020. https://missilethreat.csis.org/missile/hwasong-14/.

———. 2019e. "JL-2 (Ju Lang-2/CSS-NX-14)." *Missile Threat.* 7 October. Accessed 23 March 2020. https://missilethreat.csis.org/missile/jl-2/.

———. 2019f. "Patriot." *Missile Threat.* 4 November. Accessed 23 March 2020. https://missilethreat.csis.org/system/patriot/.

———. 2019g. "SS-N-23 Skiff." *Missile Threat*. 22 November. Accessed 23 March 2020. https://missilethreat.csis.org/missile/ss-n-23/.

———. 2020a. "Hwasong-15 (KN-22)." *Missile Threat.* 16 January. Accessed 23 March2020. https://missilethreat.csis.org/missile/hwasong-15-kn-22/.

———. 2020b. "Missiles of China." *Missile Threat.* 13 January. Accessed 23 March 2020. https://missilethreat.csis.org/country/china/.

CGSC Learning Resource Center. 2020. Combined Arms Research Library. E-mail submission. 13 April. Reviewed for grammar, punctuation, and clarity of expression.

Congressional Research Service. 2019. *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress.* 17 December. Accessed 23 March 2020. https://fas.org/sgp/crs/weapons/RL33745.pdf.

Davidson, Phil. 2019. "House Armed Services Committee Opening Remarks." U.S. Indo-Pacific Command. 27 March 2020. Accessed 23 March 2020. https://www.pacom.mil/Media/Speeches-Testimony/Article/1797909/house-armed-services-committee-hasc-opening-remarks/.

Defense Intelligence Agency. 2017. *Russia Military Power: Building a Military to Support Great Power Aspirations.* Accessed 2 March 2020. www.dia.mil/Military-Power-Publications.

Hawaii Air National Guard, 154th Wing. n.d. Accessed 1 March 2020. https://www.154wg.ang.af.mil/Units/.

Hildreth, Steven, and Mary Nikitin. 2018. "North Korea's Nuclear and Ballistic Missile Programs." *Congressional Research Service: In Focus.* 2018. Accessed 1 March 2020. www.crs.gov.

Jane's. 2019. "Korea, North: Strategic Weapon Systems: Ballistic Missiles." *Jane's Sentinel Security Assessment – China and Northeast Asia*. 3 October.

Johnson-Freese, Joan, and Ralph Savelsberg. 2013. "Why Russia Keeps Moving the Football on European Missile Defense: Politics." *Breaking Defense.* 17 October. Accessed 22 March 2020. https://breakingdefense.com/2013/10/why-russia-keeps-moving-the-football-on-european-missile-defense-politics/.

Karako, Thomas. 2009. "The Missile Defense Review." *Strategic Studies Quarterly* (Summer): 3-15.

Kristensen, Hans M., and Robert Norris. 2018. "Chinese Nuclear Forces." *Bulletin of the Atomic Scientists* 74, no. 4: 289-295. DOI: 10.1080/00963402.2018.1486620.

Merriam-Webster Dictionary. 2011. Accessed 23 March 2020. https://www.merriam-webster.com/dictionary/.

Missile Defense Advocacy Alliance. 2020a. "AN/MPQ-53/65 Radar: U.S. Missile Defense, Sensor." Accessed 22 March 2020. https://missiledefenseadvocacy.org/defense-systems/anmpq-5365-radar/.

———. 2020b. "Sea-Based X-Band Radar (SBX)." Accessed 22 March 2020. https://missiledefenseadvocacy.org/defense-systems/sea-based-x-band-radar-sbx/.

Missile Defense Agency. 2008. "A Brief History of the Sea-Based X-Band Radar-1." Missile Defense Agency Fact Sheet. 1 May. Accessed 20 March 2020. https://www.mda.mil/global/documents/pdf/sbx.pdf.

———. 2014. "Fact Sheet: Ground-based Midcourse Defense." Missile Defense Agency Fact Sheet. 4 June. Accessed 20 March 2020. https://www.mda.mil/global/documents/pdf/gmdfacts.pdf.

———. 2016. "Aegis Ashore." Missile Defense Agency Fact Sheet. 28 July. Accessed 23 March 2020. https://www.mda.mil/global/documents/pdf/aegis_ashore.pdf.

———. 2017. "Space Tracking and Surveillance System." Missile Defense Agency Fact Sheet. 27 March. Accessed 25 March 2020. https://www.mda.mil/global/documents/pdf/stss.pdf.

———. 2020. "Elements: Aegis Ballistic Missile Defense." Missile Defense Agency Fact Sheet. 12 March. Accessed 23 March 2020. https://www.mda.mil/global/documents/pdf/aegis_ashore.pdf.

Missile Defense Project. 2018a. "Missiles of China," *Missile Threat.* CSIS. 14 June. Accessed 23 March 2020. https://missilethreat.csis.org/country/china/.

———. 2018b. "Missiles of North Korea," *Missile Threat.* CSIS. 14 June. Accessed 23 March 2020. https://missilethreat.csis.org/country/dprk/.

———. 2018c. “Missiles of Russia,” *Missile Threat.* CSIS. 14 June. Accessed 23 March 2020. https://missilethreat.csis.org/country/russia/.

Naval Technology. 2020. “Arleigh Burke-Class (Aegis) Destroyer.” Accessed 27 March 2020. https://www.naval-technology.com/projects/burke/.

Pacific Air Forces. 2014. “613th Air Operations Center.” 15 December. Accessed 1 March 2020. https://www.pacaf.af.mil/Info/Fact-Sheets/Display/Article/909886/613th-air-operations-center/.

Parsch, Andreas. 2007. “Directory of U.S. Military Rockets and Missiles: Appendix 4: Undesignated Vehicles GBI.” Accessed 29 March 2020. http://www.designation-systems.net/dusrm/app4/gbi.html.

Shepardson, Peter. 1998. “Annexing Hawaii: The Real Story.” *Cultural Survival Quarterly Magazine* (December). Accessed 1 March 2020. http://sinodefence.com/df-5/.

Sino Defence. 2017. “DF-5.” 25 September. Accessed 31 March 2020. http://sinodefence.com/df-5/.

U.S. Defense Intelligence Agency. 2017. “Russia Military Power: Building a Military to Support Great Power Aspirations.” Accessed 1 March 2020. www.dia.mil/Military-Power-Publications.

U.S. Department of Defense. 2015. “Missile Defense Agency Fact Sheet: Ground-Based Midcourse Defense.” May. Accessed 3 March 2020. https://www.mda.mil/global/documents/pdf/gmdfacts.pdf.

———. 2016a. “Missile Defense Agency Fact Sheet: Aegis Ashore.” June. Accessed 3 March 2020. https://www.mda.mil/global/documents/pdf/aegis_ashore.pdf.

———. 2016b. “Missile Defense Agency Fact Sheet: Aegis Ballistic Missile Defense.” December. Accessed 3 March 2020. https://www.mda.mil/global/documents/pdf/aegis.pdf.

———. 2016c. “Missile Defense Agency Fact Sheet: Patriot Advanced Capability-3.” 3 June. Accessed 3 March 2020. https://www.mda.mil/global/documents/pdf/pac3.pdf.

———. 2018a. “Missile Defense Agency Fact Sheet: Terminal High Altitude Area Defense.” September. Accessed 3 March 2020. https://www.mda.mil/global/documents/pdf/thaad.pdf.

———. 2018b. Office of the Secretary of Defense: *Nuclear Posture Review 2018.* Washington, DC: Department of Defense, December.

———. 2018c. *Summary of the 2018 National Defense Strategy of the United States of America*. Washington, DC: Department of Defense.

———. 2019. Office of the Secretary of Defense Report: *2019 Missile Defense Review*. Washington, DC: Department of Defense.

U.S. Economic and Security Review Commission. 2019. *2019 Report to Congress of the U.S.-China Economic and Security Review Commission*. Washington, DC: Department of Defense, November.

U.S. Joint Chiefs of Staff. 2017. Joint Publication 3-01, *Countering Air and Missile Threats.* Washington, DC: Department of Defense, 21 April.

———. 2018. Joint Publication 3-27, *Homeland Defense*. Washington, DC: Department of Defense, 10 April.

U.S. Indo-Pacific Command. n.d. USINDOPACOM Area of Responsibility. Accessed 1 March 2020. https://www.pacom.mil/About-USINDOPACOM/USINDOPACOM-Area-of-Responsibility/.

U.S. Navy. 2017a. "Standard Missile." United States Navy Fact File. 30 January. Accessed 22 March 2020. https://www.navy.mil/navydata/fact_display.asp?cid=2200&tid=1200&ct=2.

———. 2017b. United States Navy Fact File: Cruisers CG. Official Website of the United States Navy. 9 January. Accessed 28 March 2020. https://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=800&ct=4.

———. 2020a. "Commander, Naval Surface Force, U.S. Pacific Fleet: Surface Ships (by Homeport)." America's Navy. Accessed 29 March 2020. https://www.public.navy.mil/SURFOR/Pages/PacificTheaterShips.aspx.

———. 2020b. "The U.S. Navy Arleigh Burke Class Destroyer: The Greyhounds of the Sea." America's Navy Public Website. Accessed 27 March 2020. https://www.public.navy.mil/surfor/Pages/Arleigh-Burke-Destroyer.aspx.

U.S. President. 2017. *National Security Strategy of the United States of America.* Washington, DC: Department of Defense, December.

Wellerstein, Alex. 2020. "Nukemap." Accessed 23 March 2020. https://nuclearsecrecy.com/nukemap/.

Wikipedia contributors. 2020. "Molniya orbit." Wikipedia, The Free Encyclopedia. Accessed 26 March 2020. https://en.wikipedia.org/w/index.php?title=Molniya_orbit&oldid=946708608.

Williams, Ian. 2018a. “Defense Support Program (DSP).” *Missile Threat*. 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/defsys/dsp/.

———. 2018b. “Sea-based X-band Radar (SBX).” *Missile Threat.* 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/defsys/sbx/.

Williams, Ian, and Masao Dahlgren. 2019. “More Than Missiles: China Previews its New Way of War.” *Missile Threat.* 16 October. Accessed 23 March 2020. https://missilethreat.csis.org/more-than-missiles-china-previews-its-new-way-of-war/.

Williams, Ian, Tom Karako, and Wes Rumbaugh. 2018. “Missile Defense 2020: Next Steps for Defending the Homeland.” *Missile Threat*. 15 June. Accessed 23 March 2020. https://missilethreat.csis.org/missile-defense-2020/.

Woolf, Amy. 2019. “Russia’s Nuclear Weapons: Doctrine, Forces, and Modernization.” Congressional Research Service Report. 5 August. Accessed 5 March 2020. https://crsreports.congress.gov.

World Population Review. 2020. “Hawaii Population.” 17 February. Accessed 1 March 2020. https://worldpopulationreview.com/states/hawaii-population/.