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COMPARISON OF NAVAL ACQUISITION EFFICIENCY BETWEEN THE UNITED STATES AND CHINA

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THESIS

COMPARISON OF NAVAL ACQUISITION EFFICIENCY BETWEEN THE UNITED STATES AND CHINA

by

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The People's Republic of China has emerged as the most significant long-term strategic competitor to the United States on the world stage. To accomplish this, China has made substantial investments in modern naval systems. In order to understand how successful China has been in this effort, an understanding of its acquisition system is required.

Different countries use different processes for the acquisition of defense systems. Currently, there is not a standard method for comparing the efficiency of acquisition systems between the United States and other nations. The purpose of this research was to develop a framework that can be used to accomplish this task and to then demonstrate that framework on the United States' and China's naval shipbuilding programs.

The results of this research identified 10 key factors that affect a country's acquisition efficiency. While the United States' shipbuilding program outperforms China's in seven of these areas, China's leads in two key factors: cost and schedule performance. This indicates that although the United States has a more efficient acquisition system overall, China is still able to produce warships faster and at a lower cost. In order to maintain its strategic advantage on the world stage, the United States must work to ensure that its acquisition system remains ahead overall and closes the gap when it comes to cost and schedule.

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COMPARISON OF NAVAL ACQUISITION EFFICIENCY BETWEEN THE UNITED STATES AND CHINA

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LIST OF ACRONYMS AND ABBREVIATIONS

AT&L	Acquisition, Technology, and Logistics
BBC	block buy contracting
BBP	Better Buying Power
CADD	Central Military Commission Armament Development Department
CCP	Chinese Communist Party
CJCS	Chairman of the Joint Chiefs of Staff
CMC	Central Military Commission
CONOP	concept of operations
CR	continuing resolution
CRS	Congressional Research Service
DAU	Defense Acquisition University
DoD	Department of Defense
DON	Department of the Navy
DSMC	Defense Systems Management College
GAD	General Armament Department
GAO	Government Accountability Office
GLD	General Logistics Department
ICD	Initial Capabilities Document
IPT	integrated product team
JCIDS	Joint Capabilities Integration and Development System
JOC	Joint Operating Concept
JPG	Joint Programming Guidance
JROC	Joint Requirements Oversight Council
KPP	key performance parameter
LCS	Littoral Combat Ship
MOF	Ministry of Finance
MRO	military representative office
MYP	multiyear procurement
NAVSEA	Naval Sea System Command
NCCA	Navy Center for Cost Analysis

NDS	National Defense Strategy
NED	Naval Equipment Department
NMS	National Military Strategy
NPC	National People's Congress
NSS	National Security Strategy
O&S	operations and support
OUSD	Office of the Under Secretary of Defense
PLA	People's Liberation Army
PLAN	People's Liberation Army Navy
POM	Program Objectives Memorandum
PPBE	Planning, Programming, Budgeting, and Execution
PRC	People's Republic of China
QDR	Quadrennial Defense Review
R&D	research and development
ROC	Republic of China
SECDEF	Secretary of Defense
S&T	science and technology
SPC	State Planning Commission
STIC	Study of Innovation and Technology in China
U.S.	United States
USN	United States Navy

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I. INTRODUCTION

The People's Republic of China (PRC) has emerged as the most significant long-term strategic competitor to the United States on the world stage. This has been accomplished through a major military modernization effort over the last 20 years which continues to transform the PRC military, known as the People's Liberation Army (PLA), from a primarily low-tech ground force to a high-tech military capable of joint operations. To accomplish this, the PLA has made substantial investments in modern naval and air systems (Cordesman & Kendall, 2016). In order to fully understand how these investments were able to rapidly transform the PLA, an understanding of the PRC's acquisition system and how it compares to that of the Department of Defense (DoD) is necessary.

Different countries have different development processes used in the acquisition of defense systems. Currently, there is not a standard method for comparing the efficiency of acquisition systems between the United States and other nations. The development of such a framework would allow the DoD to more easily assess the acquisition processes of potential adversaries, including the PRC. It would also allow the United States to identify and potentially adapt more efficient techniques used by other countries.

A. PURPOSE OF RESEARCH

The purpose of this research is to develop a framework that can be used to compare acquisition efficiencies between countries. As part of this framework, metrics and scoring criteria are identified in order to make data from different countries comparable. This is accomplished by identifying the attributes of an acquisition system that affect its efficiency and demonstrating a method to measure these attributes. The framework is then applied to the acquisition systems of the DoD and PLA to determine which system is more efficient in the acquisition of naval vessels. This also demonstrates that the framework can be successfully applied to different countries and acquisition systems.

B. RESEARCH QUESTIONS

In order to meet the objective of developing an effective framework on acquisition efficiency, this research focuses on the following questions:

1. Primary Research Question

- How can the differences in efficiencies of the acquisition systems for naval vessels in the United States and China be identified and measured?

2. Secondary Research Questions

- What are the key acquisition processes used by the United States and China?
- Can the total life-cycle costs (development, procurement, and operations and support [O&S] costs) for similar acquisitions be compared?
- What are the differences in acquisition performance (i.e., fielded capabilities) between the United States and China?

C. SCOPE AND LIMITATIONS

Although the purpose of this research is to develop a framework that can be used to compare entire acquisition systems between countries, the scope of the data analyzed is limited to battle force ship acquisition efforts of the United States Navy (USN) and the People's Liberation Army Navy (PLAN). The battle force ships that are included in this research are those that contribute directly to combat operations, warfighting, or support missions (Department of the Navy [DON], 2016). These were selected for several key reasons. They are the most relevant platform to the USN; represent a large, complex platform that requires a large, complex acquisition system; and are key to the PRC's goal of becoming a maritime power. Because of these reasons, the PLAN has invested significant resources in them in recent years (Carlson & Bianchi, 2016).

There are two significant limitations to this research, both concerning the veracity of the data that is available. While the PRC does report some defense budget numbers, outside observers believe that the official amounts are significantly less than what China actually spends on defense. Due to this discrepancy, the data used in this research consists of third-party estimates by think tanks and other analysts. While these numbers exceed the official ones issued by the PRC, there is general agreement that the trends (such as percentage of growth) are accurate (Liff & Erickson, 2013). The second limitation is that all data used in this report is unclassified and open-source. While more accurate data is likely available at the classified level, an unclassified report allows for unlimited distribution so the framework is available to anyone who needs it.

D. METHODOLOGY

This research begins by collecting and reviewing data from DoD instructions, congressional reports, think tanks, and other outside analysts on the acquisition processes of the USN and PLAN. A literature review is then conducted on scholarly articles focused on three separate areas: measuring acquisition efficiency, comparing the U.S. acquisition system to those of other countries, and analyzing the PRC acquisition system. Next, the literature review is analyzed to determine the key factors that make up acquisition efficiency. These key factors are used to develop a framework to measure the efficiency of an acquisition system. This framework is then applied to collected data on the USN and PLAN to demonstrate its effectiveness.

E. ORGANIZATION OF REPORT

This report is composed of six chapters:

1. Chapter I provides an introduction to the purpose of the research, presents the research questions, and identifies the scope, limitations, and methodology of the research.

2. Chapter II introduces the reader to background information on acquisition systems in general and the USN and PLAN systems specifically. This includes discussion on each country’s requirements system, resource allocation system, and weapons development system.

3. Chapter III consists of a literature review of studies, reports, papers, and publications that discuss measuring acquisition and process efficiency, compare the U.S. acquisition system to other countries, and describe the Chinese acquisition system.

4. Chapter IV provides the methodology used to analyze data, identifies the metrics/ratios most relevant to calculating acquisition efficiency, and develops a framework that can be used to compare acquisition efficiency between different systems.

5. Chapter V demonstrates the use of the acquisition efficiency framework using battle force shipbuilding data for the USN and PLAN.

6. Chapter VI presents findings on the research questions, analyzes their implications, provides recommendations for the USN, and concludes with suggestions for future research.

II. BACKGROUND

This chapter discusses defense acquisition broadly and then compares the differing processes of the United States and the PRC. It begins by defining defense acquisition and identifying the three major systems of defense acquisition processes. This is centered on the macro view of defense acquisition and the various steps that all countries must go through when acquiring goods or services for their militaries.

Next, each of the three systems that make up an acquisition process is discussed in detail. The DoD and PLA processes are identified, and the roles and responsibilities of key players in each process are laid out. Finally, a summary of the major similarities and differences between the two countries' processes is provided for each of the three systems.

A. DEFENSE ACQUISITION SYSTEMS

A *defense acquisition system* can be generally defined as a process or set of processes that a country uses to convert resources into weapon systems that can be used to satisfy its national security requirements (Marcum, 2013). According to the DoD, the objective of defense acquisition is "to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price" (DoD, 2007, p. 3). Everything from research and development (R&D) and production to testing and deployment is part of an acquisition system (Schwartz, 2014).

How a country goes about managing its acquisitions depends on a variety of factors. Form of government, cultural norms, industrial base, and ability to innovate all play a role in how its acquisition system is organized. One of the biggest differences worldwide is what countries are able to produce domestically versus how much they rely on making purchases from others. Due to the large investment in research and infrastructure required, many smaller nations acquire major systems such as aircraft and ships directly from larger ones such as the United States, Russia, European countries, and the PRC (Marcum, 2013).

When comparing different acquisition systems, an analysis must recognize cultural differences and take into account that other countries do not think like the United States.

That being said, while tasks are accomplished differently, there are still some basic activities that all countries must go through as part of their acquisition process (Marcum, 2013). These activities do not always have the same formalized structure that they do in the United States, but they must be performed one way or another. Every government must on some level define the requirements of what it needs, determine the resources available to acquire it, and create a process for managing the development and procurement of that item (Kausal, Humily, Taylor, & Roller, 1999). These three tasks make up the three components of an acquisition system.

No matter how an acquisition system is structured, there must be a requirements system, resource allocation or budgeting system, and weapons development system in place to accomplish the mission. In the United States, the weapons development system is referred to as the "little a" defense acquisition system, while all three systems together are referred to as the "Big A" Defense Acquisition System (Schwartz, 2014). In order to avoid confusion, this paper always refers to all three systems together when the term *defense acquisition system* is used. When discussing the weapons development system specifically, it is referred to as such. The next three sections discuss each of the three processes and how the DoD and PLA accomplish them. These processes do not represent a completely linear approach. Each process interacts with the others on a regular basis (Brown, 2010)

B. REQUIREMENTS SYSTEM

The weapons acquisition process of a country begins when a gap is identified between what its military has and what it needs to complete its mission (Snider, 2008). This gap can be from an external threat which requires a counter to it or a new capability that is required for the armed forces (Schwartz, 2014). The process of identifying a gap begins with broad national security policies and objectives put into place by the leadership of a country. Leadership can be either civilian or military depending on the county's form of government. Once these broad objectives are made, they are turned over to the country's armed forces in order to develop the specific military requirements (Snider, 2008).

A country's military leaders are responsible for translating national security objectives into more specific strategies. These strategies often take the forms of detailed missions and operational concepts. An analysis determines if the operational forces of the country can accomplish the military strategy or if there is a gap in their ability to do so. If there is a gap, the next step is determining how it should be filled. One option is to make non-materiel changes to the existing forces of the country through training or reorganization (Snider, 2008). For example, there may be a requirement for an infantry unit that can counter both air and ground threats. If both these capabilities already exist but in separate units, a reorganization could combine the two. This is a very simple example but illustrates how a gap can be closed without acquiring a new weapon system.

If a non-materiel solution cannot close a military gap, then a materiel solution is often required. This is when the acquisition system of a country begins to take control of the process (Schwartz, 2014). A materiel solution is typically a new weapon system that will be developed domestically or purchased from another country. When determining the specifics of what a materiel solution will entail, the military leadership will often get input from the end-user of the item. Specific requirements could include the top speed of a new aircraft or the minimum range for a new cruise missile. While the armed forces are able to give input as to the specific requirements, they don’t get the last word. Factors such as politics, cost, and available technology will shape the outcome (Kausal et al., 1999).

The goal is to develop a materiel solution that best meets the national security requirements of a country within all the other constraints. When the requirements are decided upon and agreed to by all stakeholders, they are passed to the weapons development system to fulfill. It is important that these systems continue to interface with each other, however. Requirements are always changing due to new external threats or the changing priorities of a country’s leadership. A mechanism must exist in any acquisition system to adjust the requirements of a program after it has already begun (Snider, 2008).

1. U.S. Requirements Process

The Joint Capabilities Integration and Development System (JCIDS) governs how the U.S. military determines what capabilities are needed to complete its mission. Prior to 2003, the DoD used a threat-based approach known as the Requirements Generation System to counter specific threats. The creation of JCIDS constituted a major shift to a capabilities-based requirements strategy (Schwartz, 2014). The development of requirements is based on several documents, beginning with the National Security Strategy (NSS). This is a document issued by the president that lays out broad national security goals (e.g., maintaining political and economic freedom). The NSS addresses all instruments of U.S. power, including diplomacy, military, and economic (Sorenson, 2009).

The DoD takes these broad objectives and uses them to develop the National Defense Strategy (NDS). A series of strategic objectives that align with the NSS is developed as well as how they will be accomplished. The chairman of the Joint Chiefs of Staff (CJCS) then develops the ends, ways, and means by which the military will execute the NDS in the National Military Strategy (NMS). The NMS identifies national military objectives, Joint Operating Concepts (JOCs) to meet these objectives, and the force structure required. Finally, the Quadrennial Defense Review (QDR) is issued by the DoD to Congress every four years to reassess and prioritize their requirements (Sorenson, 2009). Taken together, these documents form the basis used to identify needed capabilities.

The JCIDS process reviews each of these documents to determine if there is a capabilities gap that requires a new acquisition program to solve (Schwartz, 2014). Upon review, JOCs are then turned into concepts of operation (CONOPS). These documents describe in detail how the military would execute a particular JOC. The services, combatant commanders, and other agencies then take each CONOP and conduct a capabilities-based assessment. It is during this assessment that the capabilities needed to complete a CONOP as well as any gaps are identified. If gaps exist, an Initial Capabilities Document (ICD) that defines the gap must be completed. The ICD is used to justify the development of a materiel or non-materiel solution to the gap and must be validated and approved before the weapons development process can begin (JCIDS instruction).

The Joint Requirements Oversight Council (JROC) is chaired by the vice-CJCS and is made up of the vice chiefs of staff for each service. Tasked with identifying and prioritizing capability requirements, the JROC is responsible for approving or disapproving an ICD. One of the reasons for this process is to make sure that capabilities are looked at from a joint perspective and one service is not entering into a new acquisition program to duplicate a capability another service already possesses (Sorenson, 2009). As part of this process, the JROC will review the capabilities needed, validate they do not currently exist, and verify that they should be pursued. Assuming the JROC approves the ICD and recommends a materiel solution, the ICD is turned over to the weapons development system to find and procure that solution (Schwartz, 2014). The weapons development system continues to interact with JCIDS throughout the life cycle of the program as requirements change. At different points in the process, Capabilities Development Documents and Capabilities Production Documents must be revalidated by the JROC. It is due to these continuing requirements that the individuals in charge of requirements generation and those in charge of weapons development must continually interact and communicate throughout the course of a program (DoD, 2017).

2. PRC Requirements Process

The requirements process of the PRC begins at the top of the country's government, the Chinese Communist Party (CCP). Unlike the United States, China does not recognize multiple political parties. The CCP is the ultimate ruling power in China and as such, sets the strategic direction for the country (Fisher, 2008). This direction is laid out in a series of five-year development plans aimed at providing strategic direction to the various branches of government. These plans set the CCP's priorities and include specific benchmarks for meeting them. Currently, the PRC is operating under the 13th Five-Year Plan, which covers 2016–2020. Some of the major themes for this plan related to defense include an increase in nationwide R&D and an expansion of international trade. Once the five-year plans are approved by the National People's Congress (NPC), each ministry is responsible for developing a strategy to implement its portion (Koleski, 2017).

The PLA works directly with the CCP to ensure that its vision for the country is carried out. Unlike other nations, the Chinese military is not a neutral party in regards to national politics. The PLA works directly for the CCP, not the government. This relationship is solidified through the Central Military Commission (CMC), a civilian-led organization that exercises oversight over the PLA (Fisher, 2008). The PLA implements the CCP's five-year plans through a series of defense white papers. These papers are typically issued every two years. The most recent, issued in 2015, is titled *China's Military*

Strategy and lays out the strategic tasks the PLA should be prepared to undertake. These tasks include protecting China's sovereign territory, safeguarding overseas interests, and unifying China. While Taiwan is not explicitly mentioned, regaining control of the island is what *unification* refers to. The document also emphasizes that in order to meet these strategic objectives, the PLA must continue to modernize (Cordesman & Kendall, 2016).

Once a defense white paper is released outlining new strategic objectives, the PLA and its subordinates, such as the PLAN, begin the process of identifying threats that could prevent them from meeting these objectives. Currently, PLA military strategists view the United States as the biggest threat to their national security objectives. On a large scale, they see the United States as trying to contain China's rise on the world stage. On a smaller scale, they view American intervention in a conflict with Taiwan or islands in the South China Sea as being the most likely scenarios in which the United States and China would enter into armed conflict. These threats drive the desires of PLA strategists to develop capabilities that can counter those that the U.S. military would likely use against them. Examples include advanced anti-ship cruise missiles, anti-satellite technology, and fifth generation fighter jets (Crane, Cliff, Medeiros, Mulvenon, & Overholt, 2005).

Once a list of desired capabilities is drawn up by the armed forces, the priority in which they are addressed is mostly political in nature. Special committees made up of party members, military representatives, and industry determine what programs will get the resources to move forward (Puska, Shraberg, Alderman, & Allen, 2014). When a program is approved, it is included in a five-year weapons construction plan issued by the NPC. The specific technical requirements for the weapon system are then developed. This is accomplished through a comprehensive feasibility study conducted jointly by industry and the end-users in the field. According to Cheung (2014b), the purpose of this study is to "examine the operational needs of war-fighters for the equipment, tactical and technical requirements and specifications, and acquisition, and the life-cycle costs of producing them. The feasibility study provides the basis for drawing up R&D work contracts" (p. 48).

For example, as part of China's strategy to counter the United States, the PLAN has been tasked with shifting from a "near seas active defense" strategy to a "far seas protection" strategy (Carlson & Bianchi, 2016). This would require the production of ships that can sustain themselves for longer periods at sea. A feasibility study conducted by the Naval Equipment Department (NED) would determine the fleet's needs for propulsion, storerooms, berthing, and so forth, in order to meet this new mission. In consultation with the CMC Armament Development Department (CADD), formerly known as the General Armament Department (GAD), the feasibility study would have to be approved along with an overall project plan. Once these documents are completed, the acquisition of the ship can formally enter into the weapons development system (Pollpeter & Stokes, 2016).

C. RESOURCE ALLOCATION SYSTEM

A resource allocation, or budgeting, system is essential to any country that plans to invest resources in its military. How this allocation system looks can be very different depending on a country's form of government and spending priorities. The ability of a country to invest heavily in new defense acquisition programs can vary greatly based on a variety of economic factors, including the country's tax base and the high cost of R&D. Advanced military technology costs a lot of money to develop and limits the number of nations that can afford to invest in it. For those nations that do so, budgetary resources are still limited. Factors such as the recent global financial crisis have put an even larger strain on military budgets worldwide (Marcum & Milshyn, 2014).

It is because resources are limited that nations must have some kind of system in place to assign the right amount of money to the right programs. This ensures that their armed forces will be the most effective at meeting national security objectives given their monetary constraints. Allocating resources for the military begins with the military determining the resources it needs to satisfy a country's national security goals. Since major weapons programs can take years to complete, military planners must be able to think ahead and estimate what they will require well into the future (Sorenson, 2009). The military must then request money from whatever authority controls that nation's overall budget. Often, the priorities of national leadership may not be the same as the armed forces. This may cause there to be a shortfall between the money the military requests versus what it is given. Due to these shortfalls, a resource allocation system must have a method to prioritize the requests that a military generates (Kausal et al., 1999).

Once a military has planned for what it needs and knows what funds it will have available, its resource allocation system must allow for the creation of some kind of budget. Candreva (2008) defines a *budget* as “a quantified, planned course of action over a definitive time period” (p. 194). In other words, it lays out what a military will spend its money on and when it will spend it. A military budget must include money not only for acquisition programs, but also for routine requirements such as personnel, maintenance, and facilities. Once a budget is completed, the money must be spent efficiently and effectively. It is in this step that the resource management system must interface with the weapons development system to ensure that weapon programs stay on budget and schedule without sacrificing capability (Sorenson, 2009).

1. U.S. Resource Allocation Process

The Planning, Programming, Budget, and Execution (PPBE) system is the resource allocation process used by the DoD. This system is unique among the other departments of the U.S. government, which use their own systems to generate budget inputs. The first phase of the process, planning, overlaps with the requirements generation process. The primary documents used to shape JCIDS—the NSS, NDS, NMS, and QDR—also form the backbone for the planning phase (Brown, 2010). Using these documents to make informed decisions on force structure and requirements, the secretary of defense (SECDEF) issues the Joint Programming Guidance (JPG) to the services. This document lays out the priorities and objectives for each branch of the military and sets fiscal constraints that each service must follow when meeting these goals (Candreva, 2008).

The next two phases of PPBE, programming and budgeting, occur concurrently and begin once the JPG is issued. During the programming phase, each service uses the JPG to create its Program Objectives Memorandum (POM). The POM is a five-year budget proposal that takes the available resources from the JPG and matches them against each service’s priorities for acquisition programs. Each service approaches its POM submission differently (Brown, 2010). The USN conducts a capability-based analysis across all areas of the service ranging from air to subsurface warfare. It then determines what programs are most needed to meet the objectives of the JPG and prioritizes these programs in its POM.

Each POM is reviewed by the SECDEF, and final decisions on what programs to move forward with are issued in a Program Decision Memorandum. Deciding what programs to pursue is a long process and because of this, budgeting for these programs, the third phase of PPBE, must take place at the same time (Candreva, 2008).

In the budgeting phase, the first year of the POM is converted into a Budget Estimate Submission. All the programs included in the first year of the POM are priced to their most likely estimated cost, and this becomes the DoD's budget submission to the president's Office of Management and Budget (Brown, 2010). In addition to estimating how much a program will cost, the budgeting phase also determines how money will be phased over the course of time on long programs. This requires significant overlap with the weapons development system to determine how much money is needed at different points throughout a program's life cycle. While program decisions are not scrutinized much by Congress, the amount of money that goes into those programs is. Since dollar amounts have such high visibility, the DoD conducts comprehensive reviews to ensure that its budget requests are accurate and complete (Sorenson, 2009).

The final phase of PPBE, execution, begins once the president signs the appropriations legislation and funds are made available to the DoD. During this phase, money is spent following the plan laid out in the DoD's budget with deviations approved by Congress. Specific programs are graded on their ability to execute funds based on the approved plans for that program. Programs that fall significantly off target risk having their funding revaluated in the future. While money for the current fiscal year is being executed, the PPBE process starts over or continues for future fiscal years (Brown, 2010).

2. PRC Resource Allocation Process

The beginning of the PRC resource allocation process overlaps significantly with its requirements generation process. This begins when the CCP issues its five-year plan, setting its priorities for the country going forward. The Ministry of Finance (MOF) uses this document to draft the national budget for the corresponding five-year period. As part of this effort, the Defense Bureau at the civilian State Planning Commission (SPC), part of the State Council, is responsible for developing the defense portion of the budget. Using the defense white papers as a guide, the General Logistics Department (GLD) of the CMC submits a draft five-year budget plan to the Defense Bureau. This contains a weapons construction plan with all the major programs that the military is requesting, as well as routine funding requirements for items such as manpower and O&S. Once this draft five-year budget is received by the SPC, the approval process begins (Singh, 1998).

The SPC and MOF take the inputs from the CMC as well as other governmental departments and send a draft five-year budget to the CCP for review. Once that review is completed, it is sent to the NPC for approval. During this review and approval process, the CCP must determine the right mix of military and domestic spending to meet its long-term policy goals. Once the five-year defense budget is approved by the NPC, it is used as a basis for the annual defense budget (Singh, 1998). The process of developing the annual budget is a fairly structured system that is one of the few processes in which the PLA has formal interaction with the rest of the PRC government. Using a "down-up-down" approach, the annual budget follows the Chinese fiscal calendar beginning with the rollout of a national budget target for the following year in March (Crane et al., 2005).

Considering this budget target, and using the approved five-year budget as a guide, the MOF and State Council determine a top-line military expenditure number, or allocation plan. In April, they provide this number to the CMC, which is responsible for planning all military expenditures. The GLD then sends funding targets to the individual military districts as well as services such as the PLAN. The districts and services prepare bids, called "investigation and augmentation" reports, which represent their program and budget needs for the year. This process takes place throughout the summer and begins with individual unit requirements being passed up to the district, then to regional chains of command. CCP representatives must approve the request at each level of the process until all bids have been received (Crane et al., 2005).

In November, once all bids have been received, the GLD sends a draft annual budget to the CMC. The CMC makes any necessary changes and submits a budget package to the MOF in January. This package includes the CMC's budget as well as its plan for execution. The MOF takes this budget request under consideration and announces an updated military allocation number for the year in March (Crane et al., 2005). This declared number represents the official PLA budget that is reported internationally. The amount of defense spending in China is significantly higher, however. Supplemental revenue from other departments, state and local governments, and commercial interests owned by the PLA all contribute to PRC defense spending. Since 2010, DoD estimates of China's actual defense spending range from ~20%–70% higher than the official numbers, although the gap has been closing over time (Cordesman & Kendall, 2016).

D. WEAPONS DEVELOPMENT SYSTEM

The third and final component of a defense acquisition system is a weapons development system. For a weapon system program to be successful, there must be a formal and identifiable process to manage the system from cradle to grave. While the exact details of the process will vary, there are generally different phases that a program moves through and certain requirements to pass from one phase to the next (Kausal & Markowski, 2000). Taken together, the different phases of an acquisition program are known as the acquisition life cycle. According to Brown (2010), "The life cycle process takes the program through determination of mission needs; research; development; production; deployment; support; upgrade; and finally, demilitarization and disposal" (p. 42). When calculating the costs of a program, the total is more than just what it takes to physically build the system. Costs related to every phase must be considered when making decisions.

Most weapons development systems begin with an R&D phase that will set the stage for the rest of the program. How a country conducts its R&D is primarily dependent on its domestic science and technology (S&T) capability. Different methods include completely indigenous research, licensing, purchasing of technology, and even theft of technology through espionage. Other factors, such as the availability of funding and the overlapping research between military and civilian needs, will also influence R&D programs (Marcum, 2013). Once R&D is completed, a weapons development system typically moves into some type of prototype and testing phase. It is here that a system is developed and proven to be a solution to the military's need. Once that is completed, production and then deployment of the new system to the operating forces can begin. After deployment, the weapons development system will continue to support the program with logistical support, system upgrades, and eventual phasing out of use (Brown, 2010).

Every country's weapons development process is unique in how it is structured. One thing that is similar is the goal of a weapons development system: to manage the cost, schedule, and performance benchmarks of a project. Known collectively as the *triple constraint*, these variables are the primary measures of success in any project (Rendon & Snider, 2008). Meeting the cost goal means staying within budget throughout the program's life cycle. Maintaining schedule means delivering the product to the user on time. Finally, staying within performance parameters means that the system meets the capability requirements defined at the start of the program (Brown, 2010). Often, sacrifices must be made in one variable to meet the other goals. The weapons development system must regularly interact with the requirements and resource allocation systems to reconcile conflicts between cost, schedule, and performance (DoD, 2017).

1. U.S. Weapons Development System

The weapons development system in the United States, also referred to as the Defense Acquisition Management System, is the process used by the DoD to research, develop, and purchase new weapon systems. Throughout the process, there are a series of milestones that a program must reach before entering the next phase of the system. A program office made up of subject matter experts will guide the program through these milestones and work to make sure that the cost, schedule, and performance metrics are met. While the process has the same general structure for all programs, it can vary considerably depending on the type of acquisition that is being conducted. Building a new class of ship is very different from developing a new software program (Schwartz, 2014).

The process described from this point forward is the procedure that the DoD follows for a hardware intensive program. This model is used to develop both military and commercial systems and has been adapted for major weapons platforms such as warships. In addition to this process, the DoD has several others including ones for software intensive programs, accelerated acquisition programs, and hybrid acquisition programs (DoD, 2017). The hardware intensive process consists of five phases with three milestone decisions. The first phase, Materiel Solutions Analysis, begins when a review of the ICD determines a materiel solution to a capability gap is needed. The purpose of this phase is to then assess potential materiel solutions that will satisfy this ICD. This is done through an analysis of alternatives, which could include modifying an existing program, purchasing a commercial-off-the-shelf item, or developing a whole new system. Once this analysis is completed and a solution is identified, the program can complete a Milestone A review and exit to the next phase (DoD, 2017).

The purpose of the second phase, Technology Maturation and Risk Reduction, is to develop the set of technologies that will be involved in the system and demonstrate a prototype. During this phase, a prototype of the technology must be demonstrated in a relevant environment. Once this is achieved and manufacturing risks are identified, a Milestone B review is completed. The program becomes a program of record and exits to the next phase (DoD, 2017). The purpose of the third phase of the weapons development system, Engineering and Manufacturing Development, is to develop a capability and an affordable manufacturing process. In addition, a production prototype must be tested in an operational environment. Once this is done and the manufacturing process is demonstrated, the program can complete a Milestone C review and exit this phase (DoD, 2017).

The fourth phase of the system is Production and Deployment. The purpose of this phase is to achieve an operational capability that meets the needs of the mission and users. To enter, there must be successful testing, no significant manufacturing risks, a demonstration of affordability, and full funding. The phase begins with low-rate initial production and ramps up to full-rate production. During this phase, the system is proven to be mission capable through actual operations. The program exits this phase when the system has full operational capability and deployment is completed (DoD, 2017). The program then enters the Operations and Support phase, whose purpose is cost-effective life-cycle sustainment. During this phase, the system will be regularly maintained and upgraded until the system reaches the end of its use and is fully disposed of (DoD, 2017).

2. PRC Weapons Development System

The PRC management system is a seven-step process that takes a weapon system from concept to disposal. Up until 2016, the GAD had primary responsibility for all PLA acquisition programs, regardless of service. This proved to be ineffective because the GAD was primarily an Army-focused entity and other service equivalents, such as the NED, were subordinate to it. The CADD was created to provide centralized management over all the services and is now responsible for oversight over the PRC weapons development system (Cheung, 2017). There are slight variations to the PRC process based on the type of system being developed. This paper concentrates on the military shipbuilding system used by the PLAN. This process is overseen by the NED with assistance from the CADD and other governmental research agencies (Pollpeter & Stokes, 2016).

The first stage in the process, Pre-Research, overlaps with the requirements generation process. The activities in this phase include "initial exploration of ship requirements and basic technological research" (Pollpeter & Stokes, 2016, p. 180). In addition, an analysis of future funding levels, technology, and manufacturing ability is conducted to project what resources will be available. These activities assist in the development of the feasibility study required to get a program approved as part of the military budget (Puska, Shraberg et al., 2014). During the second stage, Validation, "military needs, research and manufacturing requirements, operational functions, and life-cycle costs are assessed" (Puska, Shraberg et al., 2014, p. 3). This assessment forms the basis for determining the "R&D General Requirements" and proof of concept of the program. These are reviewed by the CADD and must be approved by the CMC before the program can enter the next phase of the process (Pollpeter & Stokes, 2016).

The third stage is referred to as the Planning phase. Its focus is on initial technology research, preliminary design, and the development of guidelines for the program. Military representatives working for CADD lead this effort and are responsible for reviewing the proposed concept. As part of this requirement, Puska, Shraberg et al. (2014) state that they must "ensure reliability, pricing, standardization, software integration, and interoperability" (p. 4). This review leads to the creation of two documents that set CADD's expectations for the rest of the process, the General Requirements for Equipment

Development and the Integrated Demonstration Plan. Once these are completed, a contract is signed to begin developing the physical ship (Puska, Shraberg et al., 2014). This contract allows the program to enter into the fourth phase, Engineering and R&D.

The fourth phase is the longest in the process and is where 60%–80% of project funds are spent. It is in this phase that individual components of the weapon system are developed, tested, and integrated with one another (Puska, Shraberg et al., 2014). For ships specifically, the construction and launch of a prototype is completed as well as preliminary sea trials. Production design also takes place to determine how the ship will be constructed on a larger scale. This phase ends when a finalized design is submitted for approval and the project enters into the Product Finalization phase (Pollpeter & Stokes, 2016). This phase begins with testing of the final prototype by both industry and the end-user. This testing finalizes the production design, and an initial batch of production units is completed and tested (Cheung, 2014b). After input from users, production will ramp up, and the phase will end when all required units are produced (Puska, Shraberg et al., 2014).

The sixth phase of the process is known as the Employment phase and can overlap with Product Finalization as ships or other systems are delivered. In this phase, maintenance, operations, training, and sustainment activities for ships are carried out (Pollpeter & Stokes, 2016). This is a process that is not always followed as planned, which has resulted in systems having performance issues and not making it the end of their life expectancy. The final phase of the PRC weapons development system is the Retirement phase. During this stage, all activities needed to dispose of a ship are carried out. This includes everything from preparing a ship for foreign military sales or dismantling it for scrap. Once all systems in a program are retired, the weapons development process for that system officially ends (Puska, Shraberg et al., 2014)

E. COMPARISON

The acquisition processes used by the USN and PLAN are similar in many respects but also have some significant differences. For the requirements generation system, strategy documents issued by civilian leadership start the process for both countries. The portions of the PRC five-year plans that deal with defense parallel the NSS, while the PRC defense white papers parallel the NDS. In addition, both nations have a process for which end-users in the armed forces can give input on the specific requirements of a particular weapons program. This is reflected in the similarity of the ICD used in the JCIDS process and the feasibility study conducted by the PLA. The biggest difference in the requirements generation systems is that the U.S. system is capabilities-based while the PRC system is threat-based. JCIDS is used to develop capabilities that can help the United States meet the goals of the NSS. Conversely, the PRC looks at how to respond to threats that will prevent it from meeting its national security goals. Another big difference is how much more structured the U.S. program is. While the PRC system does have some structure, there is a lot of ambiguity and subjectivity when determining which programs will be approved to continue (Puska, Shraberg et al., 2014).

The resource allocation systems of the two countries are similar in that they both involve significant interaction between military and civilian leadership. The armed services in each country request the resources they need to carry out their missions, while the civilian leadership decides what is approved and funded. In both cases, this can be a more political than practical process. Each country also has a structured budget process with built-in deadlines for when budget requests must be submitted. In the United States, continuing resolutions (CRs) are a challenge to the military because it is forced to plan without knowing how much money will be available. This problem is also present in China because the top-line military expenditure number often arrives later than the April deadline (Crane et al., 2005). The resource allocation systems of the countries are different in that the U.S. system is a much more formalized process, particularly in regards to programming. There are defined steps required to get programs approved such as the JPG and POM process. The PRC equivalent is much less formal and does not require the same level of documentation and review. In addition, the U.S. system has separate programming and budgeting functions, while these are part of the same process in the PRC.

Finally, both weapons development systems are life-cycle focused from concept approval until retirement (five phases for the United States and seven for China). There is a series of milestones in each process that require some kind of higher level review before the program can move forward. These milestones occur at similar points in the program life cycle. Milestone A of the U.S. system approves a materiel solution and is equivalent to the proof of concept approval at the end of the PRC Validation phase. Milestone B, after technology is demonstrated, is similar to the approval required after the technology development of the Planning phase. Lastly, Milestone C, which is required to enter production after a manufacturing process is developed, is equivalent to the PRC approval process needed to exit the Engineering and R&D phase. The biggest area in which the systems differ is in how new technology is acquired. Most U.S. research is done domestically as part of a program, while the PRC uses an absorption method of obtaining new technologies through outside means. This difference affects the whole PRC acquisition process and is discussed in detail later in this report (Cheung, 2017).

F. CONCLUSION

This chapter provided background information on acquisition processes in general, along with discussion on each of the three systems involved in an acquisition process. The requirements generation, resource allocation, and weapons development systems of the United States and PRC were then discussed in detail. The chapter concluded with a brief analysis of the major similarities and differences between the two countries' systems, which are summarized in Table 1. In the next chapter, a literature review of relevant research is discussed.

Table 1. Comparison of the U.S. and PRC Acquisition Processes

System	U.S.	PRC
Requirements Generation	• A capability-based system sets requirements. • Civilian leaders set priorities. • The NSS sets broad objectives. • The NDS sets defense priorities. • The ICD provides end-user input on requirements as part of the JCIDS process. • Decision making is structured.	• A threat-based system sets requirements. • Civilian leaders set priorities. • The five-year plan sets broad objectives. • The Defense white papers set defense priorities. • A feasibility study provides end-user input on requirements. • Decision making is ambiguous.

System	U.S.	PRC
Resource Allocation	• PPBE process is formalized with multiple steps. • The military makes program and budget requests. • Civilian leadership are final decision-making authorities. • CRs delay long-term planning. • The fiscal calendar sets deadlines. • There are separate programming and budgeting functions.	• Resource allocation is a less formal process. • The military makes program and budget requests. • Civilian leadership are final decision-making authorities. • Delays in establishing top-line numbers hurt long-term planning. • The fiscal calendar sets deadlines. • Programming and budgeting functions are a single process.
Weapons Development	• A five-phase life-cycle process is used for weapons development. • Milestone A is reached after materiel solution is approved. • Milestone B is reached after technology is demonstrated. • Milestone C is reached prior to entering production • Domestic R&D is conducted to acquire new technology **<u>U.S. Life-Cycle Phases</u>** **Phase 1:** Materiel Solutions Analysis **Phase 2:** Technology Maturation & Risk Reduction **Phase 3:** Engineering & Manufacturing Development **Phase 4:** Production & Deployment **Phase 5:** Operations and Support	• A seven-phase life-cycle process is used for weapons development. • The first milestone is approval of a proof of concept. • A second milestone is reached after technology development. • A third milestone is needed to exit engineering/R&D phase. • New technology is acquired through absorption from other. **<u>PRC Life-Cycle Phases</u>** **Phase 1:** Pre-Research **Phase 2:** Validation **Phase 3:** Planning **Phase 4:** Engineering and R&D **Phase 5:** Product Finalization **Phase 6:** Employment **Phase 7:** Retirement

III. LITERATURE REVIEW

This chapter starts with a discussion of measuring efficiency as it relates to U.S. defense acquisition. This begins with a review of metrics used by the DoD and the Government Accountability Office (GAO) to determine whether an acquisition process is efficient. Recent efforts by the DoD and Congress to increase acquisition efficiency in the United States are also discussed, particularly in the case of naval shipbuilding.

Next, this chapter reviews previous work that has compared the U.S. acquisition system to those of other countries. The methodology of these studies is analyzed, and factors that can be used to compare differing acquisition systems are identified.

Lastly, this chapter concludes with a discussion on previous studies of the PRC acquisition system. The focus of this analysis is to identify strengths, weaknesses, and efficiency factors of the PRC system that can be compared to the U.S. system.

A. U.S. ACQUISITION EFFICIENCY

This section discusses the various methods that the United States uses to measure its own acquisition efficiency. It begins with a review of metrics the DoD uses to grade its own efficiency. In the next two subsections, the metrics that outside observers including the GAO and Congress use to grade the DoD are analyzed. Finally, in the last subsection, literature that discusses efficiency factors specific to shipbuilding is reviewed.

1. DoD Performance Metrics

To evaluate the effectiveness and efficiency of an acquisition system, both the outcomes of that system and the effects of inputs such as resources, policies, and processes must be considered. While no scholarly work has been done to analyze acquisition efficiency, the DoD issues annual reports analyzing the institutional performance of the U.S. defense acquisition system. Although they focus on the weapons development system, these reports contain valuable insights into the overall results produced by all three systems. According to the latest report, the primary outcome of the defense acquisition system is “the value of operational capabilities delivered in time for our warfighters to address threats" (DoD, 2016, p. xiii). While this is a somewhat subjective measure, the report looks at the more objective measurements of cost, schedule, and technical performance to draw conclusions. These measurements are used to analyze trends and develop strategies that will help improve the efficiency of the DoD acquisition system (DoD, 2016).

The 2016 DoD report on the performance of the acquisition system defines *efficiency* as acquiring value to the warfighter as cheaply as possible. The first way this is analyzed is by looking at the operational performance, or value, of acquired weapon systems. This is done by rating each program on both operational effectiveness and suitability. For operational effectiveness, a system's ability to accomplish its overall mission is measured based on supportability, survivability, vulnerability, and threat. For suitability, a composite score is assigned that takes into account safety, interoperability with other systems, availability, and reliability. Using data from 1984 to 2016, the report identifies no long-term trends and concludes that there has been no significant change in the ability of the U.S. acquisition system to acquire quality systems (DoD, 2016).

The next metric examined to measure the efficiency of the acquisition system is cost performance. This is done by measuring the frequency with which programs exceed their initial cost baselines. Cost growth eventually affects the warfighter by reducing the total quantity of a system that will be produced or cutting other programs. When measuring overall cost performance, there has been a significant downward trend in critical breaches (50% over baseline cost) in recent years, indicating overall improvement (DoD, 2017). While this does show whether an acquisition system is able to operate within its budget, it is not the sole determinant of efficiency. Another measure used by the report is schedule growth, which has a more direct effect on the warfighter. A delay in schedule means a delay in delivery of a capability needed to meet mission requirements. The results of the report's analysis are mixed. While there is a downward trend in schedule growth since 1984, there was an uptick for programs started since 2009 (DoD, 2017).

The acquisition system performance report also analyzed the effect of several inputs and processes on efficiency. While it is not possible to quantify these effects, each influences the system in some way. The first input discussed was the acquisition workforce.

The report’s analysis showed an upward trend in both the number and quality of DoD acquisition professionals. The next input, the amount of sustained protests, showed a downward trend since 2001. The third input that was analyzed, the amount of competition, has been worsening due to a variety of factors. This will discourage contractors from giving the highest quality product at the lowest price possible. Finally, contractor audits were analyzed, and the report identified an upward trend in the number of contractors found to be acceptable. This indicates that the costs contractors are billing the government for are accurate, and the DoD is not being charged for costs that were not incurred (DoD, 2017).

This section reviewed metrics that the DoD uses to analyze its acquisition system. While these metrics are useful in determining what is important to the DoD internally, they do not necessarily represent metrics that can be applied by an outsider. In the next section, metrics used by the GAO to evaluate the DoD are discussed.

2. GAO Performance Metrics

In testimony before Congress in 2009, the GAO presented a series of metrics that it uses to analyze weapons programs. While related to the cost, schedule, and performance metrics used by the DoD, the GAO approach does not just analyze program results after a system is produced. It also looks at indicators throughout a program that indicate a risk of it not meeting its objectives. Taken together, all these metrics are used by the GAO to assess the health of a program from a best practices standpoint (*Measuring Value*, 2009).

The testimony first discusses knowledge metrics that are used to predict problems and identify their causes. These indicate a program’s ability to achieve the right level of knowledge at the time, which helps reduce risk. The first point assessed is whether a program’s critical technology is demonstrated in its intended environment. A failure to meet this standard indicates a risk that needed technology will delay the program or increase its cost. The second point reviewed is the completion of engineering prototypes or drawings that verify that a design is stable. This indicates that a product will meet customer requirements as well as program targets. The final point assessed is the manufacturing process. For this, the GAO ensures that the process is capable of producing consistent parts at the start of production. Taken together, these knowledge points identify potential problems early on so decision makers have an opportunity to correct them (*Measuring Value*, 2009).

The second set of metrics used by the GAO are outcome metrics used to evaluate cost, schedule, and performance. These metrics are similar to those that the DoD uses to evaluate itself and are measured by tracking changes from a program's baseline for seven data points: development cost, procurement cost, total program cost, quantities to be procured, procurement unit cost, total unit cost, and cycle time from Milestone B to IOC. These metrics are the most useful for assessing performance of individual programs (*Measuring Value*, 2009). When individual programs end up costing more than planned, other programs throughout the DoD are affected. For these reasons, the GAO also assesses all DoD acquisition programs together, which provides better insight on the acquisition system as a whole. The most recent report, issued in March 2017 and containing a portfolio of 78 major programs, contains mixed results (Sullivan, 2017). Total planned costs increased by $9.4 billion, and the average schedule delay increased by two months in the last year. Programs that have begun in the last five years showed better performance, and the total buying power of the portfolio increased by $10.7 billion (Sullivan, 2017).

The final area assessed by the GAO is a program's ability to set realistic baselines. All of the other metrics that the GAO uses to measure a program's heath are based on comparing a baseline estimate to actual performance. The GAO acknowledges, however, that these metrics are not valuable if the initial baseline is flawed. With this fact in mind, the GAO identified a set of prerequisites that must be included in a program's acquisition strategy for a baseline to be realistic. These prerequisites include the following: a clear business case for the product, separate technology and product development activities, limited product development time, early systems engineering, a commitment to fully fund the program, and prioritization of programs set from the top of the DoD. If all programs contained these prerequisites, it would be much easier to predict their cost, schedule, and performance outcomes accurately (*Measuring Value*, 2009).

3. DoD Improvement Efforts

In addition to metrics used by the DoD and GAO, another way to identify factors that affect acquisition efficiency is to look at efforts to improve the acquisition process. While not hard metrics, areas that have been targeted for improvement provide insight into what influences acquisition efficiency. The primary improvement program used by the DoD is called Better Buying Power (BBP) and is focused on continuous improvement. The latest iteration of the program, BBP 3.0, was introduced in 2014 and consists of a set of initiatives designed to ensure the DoD remains ahead of its peers in the field of military technology (Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics [OUSD(AT&L)], 2014). In a white paper introducing BBP 3.0, the DoD acknowledged that other countries are catching up technologically and there is the potential for the United States to fall behind. The goal of the BBP initiatives is to spur innovation and ensure that the United States maintains its edge in the future (OUSD[AT&L], 2014). The following is a summary of the seven major initiatives.

The first initiative is to achieve affordable programs. Services must conduct analyses to determine if the cost of a program can be afforded in future budgets. Affordability caps are established before programs begin, and those that cannot meet these caps are not allowed to continue. This forces the prioritization of requirements and requires people to make trade-offs when they want more programs than their future budgets can afford. The next initiative is to control costs throughout a program's life cycle. This requires acquisition professionals to work closely with the end-users to have an idea of what a system will cost to not only produce, but to sustain well into the future. All stakeholders must work together to establish "should cost" targets for a program and find ways to reduce program costs to meet those targets (OUSD[AT&L], 2014).

The third initiative is to incentivize productivity and innovation in both industry and government. For productivity, this is primarily achieved by using the appropriate contract type and incentive structure to reward contractors who hit the DoD's targets. For the innovation portion, the BBP encourages an increase in the use of prototyping and experimentation to advance technological capability. The next initiative is to eliminate bureaucracy and unproductive processes. In the case of bureaucracy, this means eliminating unnecessary levels of review and oversight. Unproductive processes include low-value activities and document requirements imposed on both acquisition professionals and industry. If an activity does not contribute to the core mission, it should be removed. The fifth initiative is to promote effective competition, which is considered by the DoD to be the most useful tool to control costs. The BBP program emphasizes the need to push for direct competition in programs and, if not, to create a competitive environment where there are at least some competitive pressures on a contractor (OUSD[AT&L], 2014).

The sixth initiative in the BBP program is to improve the skills of acquisition professionals in the field of services acquisition. It specifically encourages improving management of service contracts and the use of small businesses for service needs. This may not seem relevant for major weapon system programs such as shipbuilding, but there is always some kind of services acquisition involved in weapons development, such as engineering or technical support. The final initiative that makes up BBP 3.0 is improving the professionalism of the whole acquisition workforce. This starts at the top by setting higher standards for personnel in acquisition leadership and continues for rank-and-file employees by requiring stronger standards for professional certifications. For acquisition professionals at all levels, BBP emphasizes a need to create a culture of cost consciousness where everyone recognizes that resources are not unlimited and hard choices must be made to stay within budgets (OUSD[AT&L], 2014).

4. Naval Shipbuilding Efficiency

In February 2018, the USN released its long-term plan for ship construction, known as the 30-Year Shipbuilding Plan. In this plan, the USN identifies how it will meet the requirement for a 355-ship Navy as laid out in the NDS. The plan presents several methods to achieve this benchmark, including a sustained growth plan to achieve its goals in the 2050s, and an aggressive growth plan to achieve its goals in the 2030s. The acquisition system will be responsible for executing this plan and providing ways to meet these targets (DON, 2018). In congressional testimony in 2015, the Congressional Research Service (CRS) discussed acquisition efficiency and how it relates to executing a shipbuilding plan. Many of the factors that influence acquisition have an even larger effect on shipbuilding programs. Other factors, such as the contracting mechanism used and the state of the industrial base, have unique effects on shipbuilding (*Acquisition Efficiency*, 2015).

Shipbuilding is a very capital-intensive acquisition program. Even after the requirements have been identified and R&D has been completed, it can take several years for a ship just to make it through the Production phase. Due to this long lead time, factors that influence efficiency have an amplified effect. The first identified by the CRS is the requirements system. The extended time it takes for a shipbuilding program to reach completion means more time for requirements to change. Responding to these changes, particularly during construction, means increased cost and schedule time, so there must be a balance between meeting requirements and containing cost. The importance of estimating life-cycle costs is also critical to shipbuilding. Some ships will remain in service for 50 years or longer, and the effect they will have on future budgets must be considered (*Acquisition Efficiency*, 2015).

In addition to acquisition efficiency factors that are amplified during shipbuilding, the CRS identified two areas with unique effects. The first of these is the contract mechanism used. The typical DoD approach to contracting is to issue an annual contract with options that can be executed if the government decides to use them. The CRS found that for some shipbuilding programs, multiyear procurement (MYP) and block buy contracting (BBC) can reduce unit costs and allow for the purchase of more ships for the same cost. For both MYP and BBC, a single contract is issued that covers several years of a program at once. This provides stability and gives a contractor the ability to optimize its workforce and production facilities. It also allows the DoD to order the most cost-effective quantity of key components with a long lead time (e.g., radars, engines, etc.). This allows suppliers to take advantage of economies of scale and lower costs. Overall, the use of one of these contracting mechanisms can cut costs up to 10%. For example, when using MYP, the USN was able to convert a planned buy of nine DDG-51 class destroyers into a 10-ship buy for the same price (*Acquisition Efficiency*, 2015).

The industrial base is another factor that uniquely affects shipbuilding acquisition efficiency. Providing shipyards with stable, predictable business allows them to reduce start-up costs, retain qualified personnel, and make capital investments in their manufacturing equipment. This all helps to reduce program costs. In addition, balancing shipbuilding across multiple yards helps to increase competition (*Acquisition Efficiency*, 2015). Over the last several decades, drawdowns in the military have led to the closures of the majority of shipyards. This has left the USN with only seven private yards to construct new ships, significantly fewer than its competitors. In order to maintain the remaining capacity, the acquisition system must ensure predictable business to industry. This requirement can conflict with the efficiencies gained from economies of scale when ordering ships in larger quantity from a single contractor (DON, 2018).

B. COMPARISONS OF ACQUISITION SYSTEMS

This section reviews the limited literature available that compares the U.S. defense acquisition system to those of other countries. Methodologies that can be used to compare differing acquisition systems are identified and discussed. First is a review of two books published by the Defense Systems Management College (DSMC) comparing the U.S. acquisition system to two collections of countries. The first book is focused on European allies and the second is focused on Asian allies. While the primary audience for these books is acquisition professionals working on projects with our allies, they still provide significant insight into the similarities and differences between acquisition systems.

A thesis comparing the U.S. acquisition system to the Republic of China (ROC), or Taiwan, is then reviewed. Written by an ROC officer attending the U.S. Air Force Institute of Technology, the thesis is primarily focused on the weapons development process. While the purpose of the thesis is to identify U.S. processes that can be applied to the ROC acquisition system, it provides a useful analysis of how an outsider assesses the U.S. acquisition system and compares it to that of his own country. All three of the sources discussed in this section were written during the late 1990s. The U.S. acquisition system, and presumably the others, have undergone some reforms and changes since this time, but the basic themes are still relevant.

1. The United States and European Allies

In the first book released by the DSMC (Kausal et al., 1999), the U.S. acquisition system is compared to that of the United Kingdom, Germany, and France. The purpose of this comparison is threefold: to provide acquisition professionals in industry and government information on the other countries for the purpose of doing business, to facilitate collaborative projects between two or more of the countries, and to identify best practices from each country that can be adapted. The book begins with a detailed analysis of each country and a background on its acquisition system. This analysis includes information on the country's history, government structure, military organization, defense acquisition process, and industrial base. After each country is analyzed individually, the authors present a comparison of all four countries' acquisition systems. Since this paper is not interested in individual acquisition processes of European countries, only the comparison chapter is discussed (Kausal et al., 1999).

Kausal et al. (1999) begin by discussing the similarities of all four countries. Each is a liberal democracy that embraces civilian control of the military. As a reflection of this, each acquisition system has some level of civilian governmental oversight. All have a formalized structure consisting of a requirements system, resource allocation system, and weapons development system. The latter for each has defined phases that a program must go through throughout its life cycle, with milestones often required to advance to the next phase. All four countries place an emphasis on developing new weapon systems in order to have the most advanced equipment available versus purchasing existing systems. This is an approach that can be traced back to the Cold War, when these countries sought to counter Soviet arms developments. Finally, each system is designed to achieve "value for money," or the most efficient way of providing weapon systems at the lowest cost. How each defines *value* varies, however (Kausal et al., 1999).

The book discusses several key areas in which the countries' acquisition systems differ, with "value for money" being the first one. In determining the value of a defense system, the book identifies four factors that governments consider: defense capability, economic impact of the project, impact on currency due to public expenditure level, and foreign sales ability of the item. In addition to considering value, the authors compare the level of defense importing/exporting and collaborative projects that the countries engage in with each other. Next, both the political and competitive environments and how they affect procurement decisions are discussed. Finally, the organizational structures of the acquisition systems are compared, with specific discussion on who is responsible for making procurement decisions. Table 2 highlights the differences between countries in each of these areas (Kausal et al., 1999).

Table 2. Acquisition Systems of the United States, UK, France, and Germany

Factor	U.S.	UK	France	Germany
Definition of Value for Money	Primarily concerned with military capability. Also uses spending for socio-economic goals.	Concerned with self-defense capability and ability to support collective defense.	Most likely to consider non-defense factors such as socio-economic goals and exports.	Primarily concerned with self-defense and support of the local industrial base.
Level of Arms Exports	Largest in world but does not consider export value when developing weapon systems.	Significant amount but export value has limited influence on requirement development.	Very high levels, particularly to third world. Export value affects requirements.	Most restrictive policy. Exports done only in certain situations such as EU trade agreements.
Level of Arms Imports	Limited. Open to some European products but requires most manufacturing be done in U.S.	Significant, particularly from the U.S. Also imports from other European countries.	Limited imports from the U.S. and European countries. Desires to be self-sufficient.	Limited imports from the U.S. and European countries. Desires to be self-sufficient.
Level of Collaboration	Overall limited. Most projects developed independently with a few exceptions.	Significant due to the cost of independent systems. Mostly with Europe but also with U.S.	Traditionally independent but has embraced collaboration due to costs.	Most frequent participant in collaborative projects of all 4. Mostly with NATO allies.

Factor	U.S.	UK	France	Germany
Political Environment	Congress has the ability to make decisions on any individual program.	Parliament approves overall budget but has limited authority for specifics.	Parliament approves long-term spending plans but not annual amounts.	All large contracts must be submitted to Parliament for review to award.
Competitive Environment	Privatized industrial base. Qualified competition used in some sectors.	Privatized industrial base. Qualified competition used in some sectors.	Some companies owned by the government. Least amount of competition.	Strong preference for competition but also uses direct awards for some.
Acquisition System Structure	Decentralized system with each branch of service having its own procurement authority. Central system for joint items.	Centralized procurement agency whose main role is to maximize business value of weapon programs.	Centralized procurement agency which balances defense and social-economic requirements.	Centralized procurement agency required to maintain separation from the armed forces.

2. The United States and Asian Allies

The second book released by the DSMC (Kausal & Markowski, 2000) focuses on comparing the U.S. acquisition system to those of Australia, Japan, South Korea, and Singapore. These countries were chosen because they are all allies that are likely to participate in collaborative projects with the United States in the future. The structure of this book is the same as the one previously discussed. After an initial discussion on each nation, the similarities and differences in their acquisition systems are explored. Like in the first book, each country has a structured process for weapons development that goes through a series of defined phases. Different levels of review are required to advance a program to the next phase. In each country, there is some level of civilian control over the military and a desire to maximize the “value for money” that defense acquisitions provide (Kausal & Markowski, 2000).

Where this book differs from the previous one is the countries themselves. The acquisition systems of these countries are not as advanced as those of Europe so they often take a different approach. Unlike the European countries, which all faced the similar threat of Soviet aggression, the threat profiles of the Asian allies vary dramatically. South Korea faces the near constant threat of attack from North Korea and this is, for the most part, the sole focus of its defense planning. Australia, on the other hand, faces no significant external threat and its requirements system reflects this. Table 3 highlights the different factors that affect the acquisition systems of these countries (Kausal et al., 1999). The United States is not included in this table because its data is the same as in Table 2.

Table 3. Acquisition Systems of Australia, Japan, South Korea, and Singapore

Factor	Australia	Japan	South Korea	Singapore
Definition of Value for Money	Considers self-defense, support for allies, and socioeconomic factors in its decisions.	Concerned with self-defense capability and support to the economy.	Self-defense capability to counter North Korea is central to all acquisition activities.	Primarily concerned with deterring aggression and protection of economic base.
Level of Arms Exports	Moderate level of exports. Considers export value when developing requirements.	Prohibits sale of arms in most instances. Does allow some level of technology transfers.	Moderate level of exports. Considers export value when developing requirements.	Limited level of exports but does consider export value when developing requirements.
Level of Arms Imports	Moderate level from the United States but preference is to manufacture products locally.	Most equipment is developed and constructed locally. Does import some from the U.S.	Significant level of imports in order to lower development costs and lead times.	Significant level of imports in order to lower development costs and lead times.
Level of Collaboration	Significant range of cooperation. Primarily with New Zealand, the U.S., and the UK.	Collaborative efforts are almost exclusively limited to those with the U.S.	Primary partner is the U.S. but also works with European and Asian allies.	Significant effort to leverage foreign expertise through R&D partnerships.

Factor	Australia	Japan	South Korea	Singapore
Political Environment	Cabinet is final decision-making authority and legislature approves topline budget.	Cabinet is final decision-making authority, with trade/finance ministers' influencers.	National Assembly can make some decisions but president is main authority.	Legislature can only approve or reject topline budget numbers and has little say in programs.
Competitive Environment	Privatized industrial base and encourages competition in order to lower program costs.	Strong, private industrial base; competition is limited with many contracts sole source.	Similar to the French model with mix of government and privately owned companies.	Privatized industrial base. Competition used for most programs but some set asides.
Acquisition System Structure	Centralized procurement agency that is independent from armed services.	Centralized procurement agency headed by civilian political appointees.	Centralized procurement agency headed by civilians but with military in key positions.	Centralized procurement agency with military members in most key positions.

3. The United States and the Republic of China

A thesis comparing the U.S. acquisition system to the ROC's (Ching-Tsung, 1997) seeks to answer the research question of how to improve acquisition management in the ROC. The author begins by conducting a literature review that provides background information on both the U.S. and ROC acquisition processes. The focus of this review is on the various managerial functions present in each system. A qualitative analysis is then done to compare both systems, identify deficiencies in the ROC system, and make recommendations on how to correct these deficiencies. This analysis is conducted by using a case study method that takes a broad look at the U.S. and ROC methods. To provide focus for the comparison, the author identifies five key functional indicators that represent managerial activities which can be compared to each other (Ching-Tsung, 1997).

The first indicator the study explores is policy and statutes that the United States and ROC have put in place. These are the governing documents that direct and control how acquisition professionals do their jobs. The next indicator compared is the acquisition process. This indicator is focused on the weapons development system of each country and compares how each country's system is divided into different phases. The third indicator discussed is the acquisition workforce training system used by each country. This is chosen because it has a significant impact on the system's ability to meet management objectives. The fourth indicator is the acquisition organizations of each country and how they are structured. Finally, the last indicator the study explores is contract management in each country. The focus of this analysis is on interaction between the government and the contractor (Ching-Tsung, 1997). Table 4 summarizes each of these five indicators and the recommendations made by the author.

Table 4. Acquisition Systems of the United States and the Republic of China

Indicator	U.S.	ROC	Recommendations
Policy and Statutes	Numerous policies and rules including the FAR govern all aspects of U.S. procurement policy for all government departments. Acquisition reform programs ongoing.	Only one governing document for procurement, limited to defense. No procurement policy office and limited socioeconomic objectives. Little acquisition reform.	Adopt the FAR structure in the ROC. Establish an acquisition policy office and begin an acquisition reform program. Use defense acquisition to expand industrial base.
Acquisition Process	Multi-phase process governs weapons development throughout the life cycle from concept approval until disposal. Teams work all phases.	Weapons development system has phases but they don't cover the whole life cycle or interact. Process ends once buying action is completed.	Include the full life cycle of a product as part of the acquisition process. Expand acquisition process on major weapon systems instead of foreign military sales.
Workforce Training System	Acquisition professionals are given in-depth training for their specific job function such as contracting or logistics. Varying	Acquisition professionals are given basic training covering all job functions. There is only one level of training for all levels of seniority	Divide the acquisition workforce into different specialties so people can become experts in a field. Begin a career development

Indicator	U.S.	ROC	Recommendations
	levels of training based on experience.	with little continuous learning.	program for advanced training.
Acquisition Workforce Organization	Very structured system with workforce members having defined specialties. Defined approval authorities make milestone decisions and source selections.	No formal acquisition positions at unit or operational levels. Each acquisition entity is somewhat independent with very little formal overarching authority over the system.	Establish more formal acquisition organizations at the lower level and in the different military components. Redesign structure based on functional components.
Contract Management	U.S. uses trained contracting professionals to negotiate with contractors and issue contracts. Variety of contract types and award criteria.	Most negotiation and contracts are issued by lawyers, not contracting officers. Contracts are awarded on only fixed price basis with price only factor.	Establish positions for contracting professionals outside of the legal community. Expand options for contract type, award criteria, and bidding.

C. THE PRC ACQUISITION SYSTEM

This section reviews previous literature written on the PRC acquisition system and highlights the strengths, weaknesses, and efficiency factors identified by this literature. While there is a significant amount of academic research focused on Chinese military modernization, most of these studies take a defense analysis or foreign affairs approach to the issue. They are focused primarily on the macro-level causes and effects of the PLA’s modernization on the world stage and do little to explore the mechanics of how that modernization has happened. Literature that analyzes the internal business and bureaucratic processes of the PRC acquisition system is limited, but the sources that do exist provide useful insights that can help compare the efficiency of the U.S. and PRC systems.

Most research analyzing the internal processes of the PRC acquisition system has been conducted by the Institute on Global Conflict and Cooperation at the University of California, San Diego. Headed by Dr. Tai Ming Cheung, this organization conducts research in a variety of defense oriented fields. One of its projects, the Study of Innovation and Technology in China (SITC), focuses on the effects of technology advances on China's society—both foreign and domestic. Its research is highlighted in the next two subsections. The following subsection analyzes a report written for the U.S. military by the RAND Corporation on the opportunities and constraints brought about by China's military modernization. The last subsection is focused specifically on the acquisition of naval ships and discusses a book on that topic.

1. Strengths and Weaknesses

In a paper written for the 2017 Naval Postgraduate School Acquisition Research Symposium, Cheung discusses the strengths and weaknesses of the Chinese acquisition system and how they affect the United States. The paper starts with a brief discussion on the overall nature of the PRC system. Two distinguishing features identified here are relevant to acquisition efficiency. The first is the nature of the regulatory system used by the PRC. China operates a command and control system that relies on coercion and threats by military authorities to get results. The primary focus of its regulators is to dictate how companies operate instead of monitoring their performance. This system is effective to a point but does not work in a market-based environment. The U.S. regulatory system takes a more independent and transparent approach, which is more effective in fostering innovation and competition (Cheung, 2017).

The second feature identified is that the Chinese primarily use an absorption method to acquire new technologies. This is in contrast to the United States and other developed nations who rely more on domestic R&D for technological advancements. Absorption has enabled the Chinese to close a wide technological gap with the United States in several areas, including naval shipbuilding. Since they do not have to spend large amounts of time and money on R&D, they gain significant savings in the cost and schedule measurements of their weapons development system. Technology is acquired in a variety of ways, including reverse engineering, espionage, and R&D agreements with other countries. A reliance on absorption does have one significant drawback. While it has allowed China to catch up to the United States in many areas, the lack of innovation associated with absorption means that China will only be able to match technologies that have already been put into service. It will not be able to exceed the United States and other rivals in performance unless it invests more into its own R&D (Cheung, 2017).

After discussing the overall nature of the PRC acquisition system, Cheung outlines some strengths that have led to positive developments in China's defense industry. These strengths have all contributed to increased acquisition efficiency for the PRC. The first is high-level leadership support. Oversight by CCP and PLA elites has helped the PRC acquisition system to reduce bureaucracy and compartmentalization, leading to a reduction in cost overruns and delays. Next, an increase in medium- and long-range planning has stabilized the requirements development system to ensure it focuses on systems that are actually needed to counter threats. Finally, an increased investment in R&D has helped increase domestic capabilities so China can begin relying less on absorption. This has been done by shifting resources away from academic institutions and into defense corporations as well as focusing on civil-military integration and developing technologies that are mutually beneficial to both sectors (Cheung, 2017).

Cheung (2017) then pivots his paper to a discussion on weaknesses of the PRC acquisition system. Most of these weaknesses are institutional in nature and a symptom of the Soviet-style system on which the PRC's system is based. There have been efforts to correct these deficiencies, but the process is slow and ongoing. The first is the lack of competition. Most contracts for major weapon systems are awarded on a sole source basis to state-owned monopolies. The next weakness is bureaucratic fragmentation. Compartmentalization exists at all levels among acquisition professionals, military end-users, politicians, and contractors. This makes the decision-making process difficult and programs hard to manage. Compartmentalization also exists among acquisition professionals themselves. Individuals assigned to R&D, contracting, testing, and other disciplines rarely interact with each other, causing significant gaps in information sharing (Cheung, 2017).

The contract management of weapons development projects is a third significant weakness in the PRC system. The PRC lacks a contracting mechanism to hold contractors accountable. While contracts do exist, they are administrative in nature and do not define cost, schedule, and performance objectives. The fourth weakness, also related to contract management, is the use of an outdated pricing system. Most contracts use a cost-plus structure that awards contractors 5% profit over their costs. There are no performance incentives that encourage contractors to keep costs low or take risks in the name of innovation. The final weakness highlighted by Cheung (2017) is the presence of significant corruption. This issue has only gotten worse as China shifts from a planned economy to a more competitive structure. Although the extent of corruption is not known—because the PLA keeps this information secret—senior leaders have identified corruption as a primary area of concern (Cheung, 2017).

Cheung (2017) closes his paper by analyzing the implications of his findings for the United States. This is broken down into three levels: geo-strategic, industrial, and acquisition. On the geo-strategic level, China's rapid transformation into a more modern defense industry has allowed it to begin conducting an arms race with the United States. In response to this threat, the United States has had to invest more into R&D in an effort to stay ahead of China technologically. At the industrial level, the rapid pace of growth in China's defense industry does not show any signs of slowing in the near future. There is a possibility that some sectors will not see improvement due to the institutional weaknesses previously discussed, but the United States must be prepared for China to continue to modernize its industrial capabilities. Finally, at the acquisition level, China's system allows it to stay ahead of the United States on cost and schedule performance measures; however, the United States is still the leader in the areas of performance and innovation. If China's acquisition system is able to close the gap in those areas, it will be able to surpass the United States in overall effectiveness (Cheung, 2017).

2. Innovation Framework

In *Forging China's Military Might*, Cheung (2014a) develops a framework for assessing innovation in the Chinese defense industry. Defined as "the transformation of ideas and knowledge into new or improved products, processes, and services for military and dual-use applications" (Cheung, 2014a, p. 3), *defense innovation* is made up of three components: technology, doctrine, and organization. These components—as well as a country's capacity, process, degree, scope, and systems of innovation—are all analyzed as part of the framework developed in the book. Many of the same factors that affect a country's ability to innovate also affect its acquisition efficiency. Of the many topics discussed in Cheung (2014a), three are most relevant for further analysis: the Chinese innovation system, the acquisition workforce, and the shipbuilding industrial base.

As noted throughout the book (Cheung, 2014a), the innovation system used by the Chinese military is continuously undergoing reform. Historically, it has used a top-down approach in which central regulatory authorities controlled R&D funding. They set the priorities for domestic research based on their own institutional needs, and any real technological advances in the defense sector came through absorption of technology. That system has been steadily changing since the turn of the century. The GAD (now the CADD) took on the role of coordinating R&D with military end-users and the S&T community. The purpose of this reform is to ensure that the limited amount of domestic research being done is on products and capabilities the military actually needs. Some of the institutional weaknesses mentioned previously, such as compartmentalization and bureaucracy, are a barrier to the success of this model. The success of reforms in those areas will have a direct effect on the success of China's emerging innovation system. For now, however, that system should be considered inferior to the United States' (Cheung, 2014b).

The next issue discussed by the book that affects acquisition efficiency is the PLA acquisition workforce (Puska, Geary, & McReynolds, 2014). Unlike the DoD, which has a robust system of civilian and military acquisition professionals, the PLA relies on a military representative office (MRO) system to perform oversight over defense contracts. MROs are staffed by active-duty military officers and located at regional offices as well as factories and research institutes. The responsibilities of an MRO are vast. An MRO is responsible for interfacing with the military end-users on requirements, overseeing the bidding process, carrying out source selection, testing, handling production oversight, and maintaining quality control. Overall, this system has proven to be ineffective. The roles and responsibilities assigned to MROs are often unclear and the training inadequate. Very junior personnel with limited experience are tasked with overseeing large factories, opening the door for corruption. The PLA has undertaken reforms to transform the MRO system into something more like the U.S. system, in which personnel specialize in a single area, such as contracting or financial management, but these efforts are still in the early stages (Puska, Geary, & McReynolds, 2014).

The last issue that affects acquisition efficiency is the Chinese industrial base. The book defines three tiers for defense industries worldwide (Bitzinger, Raska, Koh, & Wong, 2014). The United States is the only Tier 1a country, meaning that it has the ability to develop and manufacture a full range of modern military capabilities. China is rated in Tier 2c because it has a broad-based defense industry but limited capacity for R&D. China is particularly deficient in areas such as jet propulsion, avionics, electronic warfare, and sensors. One Chinese industry that has seen improvement in recent years, however, is shipbuilding. A boom in the Chinese civilian shipbuilding sector has allowed best practices to be transferred to military producers, and top leadership support has ensured increased funding for naval S&T programs. While the PRC was behind most of its regional competitors in shipbuilding 20 years ago, its industry has surpassed India and South Korea and is equal to or ahead of Japan in some areas. It still lags behind the United States and other advanced Western countries due to deficiencies in some areas, especially marine propulsion. The authors conclude that it is unlikely that China will be able to match them unless the other nations were to begin investing less in R&D. While the shipbuilding industry has made more progress than other sectors of the Chinese defense industrial base, it still has a long way to go (Bitzinger et al., 2014).

3. Opportunities and Constraints

Many researchers have tackled the issue of China's modernizing military and its implications for the United States. In a RAND Corporation report, the authors try to determine whether the PLA will have the ability to challenge the U.S. military by 2025 (Crane et al., 2015). Instead of looking at military strength as the metric for comparison, like most studies do, this report looks at economic factors that will affect the decisions of Chinese military and civilian leaders. The authors look ahead to determine whether increased societal pressures such as education, healthcare, and government pensions will divert funding away from the military and threaten its modernization. As part of this analysis, the authors consider three factors that affect acquisition efficiency from an economic perspective: the military budgeting process, the Chinese defense industry, and the effect of PLA threat perceptions on force planning (Crane et al., 2005).

Although the specifics of the Chinese budgeting process that RAND examines were discussed in Chapter II, there is one aspect that affects acquisition efficiency and warrants further analysis. That issue is the decentralized nature of PRC military spending. The official resource allocation process only applies to the central government funding provided by the CCP. There is a separate and unofficial system that military units and services use to receive and spend extrabudgetary revenue. This begins at the provincial and municipal levels where local governments are responsible for supporting the military units present in their jurisdictions. The unofficial system continues on a higher level with commercial entities that are owned by the PLA or one of its branches. The profits that these ventures produce are funneled to the armed services and distributed outside the official budget process. This additional income provided to the PLA is not an insignificant amount and is one of the factors that cause PRC military budget numbers to be understated. Acquisition efficiency is affected because individual units and services are able to spend money on pet projects with no oversight. If these funds were distributed as part of the official military budget, senior leaders would be better able to ensure that the funds were spent on projects that support national priorities (Crane et al., 2005).

The RAND report also considers whether China’s industrial sector would be able to meet the needs of the Chinese military if defense spending were to increase. Like Cheung’s work, RAND concludes that China’s defense industry is historically weak, lacks innovation, but shows signs of improvement in some areas. Several of the weaknesses that RAND identified were not discussed in the previous work, however. These all relate to the poor management capabilities of China’s state-owned defense enterprises. Some examples include extra production capacity, poor hiring practices, redundant personnel, and incorrect pricing on subcontracts. All of these issues drive up costs, which are passed directly to the PLA due to the lack of incentive-based contracts. In addition, commercial enterprises in China offer better incentives to technical talent, which deters potential employees from working in the defense sector. This means the quality and performance of end products are not as high as they could be with the right employees. RAND concludes that China has the ability to significantly reform its defense industry, but they must concentrate on providing incentives for companies to lower costs and increase innovation (Crane et al., 2005).

The last issue discussed by RAND that affects acquisition efficiency relates to the requirements generation process (Crane et al., 2005). As discussed in Chapter II of this thesis, strategic objectives are communicated to the military services through defense white papers. These white papers drive the requirements process by providing a focus to the armed forces when they determine what weapon systems are needed. RAND points out, however, that these white papers are inherently political documents. The language used and characterization of one country or another as a threat can shift dramatically in tone between one white paper and the next. The tone towards a country like the United States is sometimes more a reflection of the current state of diplomacy between the two countries than an actual change in the threat perceptions of senior leadership. This discrepancy is a potential source of misinterpretation on the part of PLA military planners and could lead them to plan requirements to counter the wrong threat (Crane et al., 2005).

4. Chinese Naval Shipbuilding

In 2015, the China Maritime Studies Institute and the U.S. Naval Institute hosted a conference at the Naval War College titled China’s Naval Shipbuilding: Progress and Challenges. The purpose of the conference was to analyze the prospects for China’s shipbuilding industry through 2030 and the implications for the United States. The presentations of the conference were compiled into a book edited by Andrew Erickson (2016) titled *Chinese Naval Shipbuilding*. This book provides remarkable insight into the shipbuilding industry in China and the process the PLAN uses to develop and produce naval vessels. Several topics in the book relate directly to the PLAN acquisition process’s efficiency and are discussed in this subsection. These include PRC warship requirements generation, shipbuilding industrial capacity, naval shipbuilding weaknesses, and implications for the United States (Erickson, 2016).

The evolution of PRC national strategic objectives have impacted the PLAN more than any other service. A gradual change in threat perceptions by Chinese leaders from land-based concerns (such as border disputes with Russia) to sea-based ones (such as a clash with the United States over Taiwan) has caused significant growth in both the resources and missions assigned to the PLAN. These increased responsibilities have driven warship requirements and caused the PLAN to develop systems that can support extended operations at sea. This has led to the need for investment in advanced radars, weapons, and fire control systems as well as ship hulls and engineering plants that can support these systems. The resources provided to the PLAN for this effort over the previous decades have resulted in a thriving shipbuilding industry, now the largest in the world. China has leveraged this asset to build a profitable commercial shipbuilding business and to support the continued expansion of the PLAN (Carlson & Bianchi, 2016).

The Chinese shipbuilding industry consists of over 250 shipyards of varying sizes and capacity. The military shipbuilding sector is much more consolidated, however. Two state-owned conglomerates, China Shipbuilding Industry Corporation and China State Shipbuilding Corporation, control all military shipbuilding. Though these conglomerates only use seven large shipyards for the military, the capacity of these yards is significant. China launched 83 large surface combatants and submarines between 2005 and 2015 with production projected to continue at this pace through 2020. This is in addition to a large number of smaller craft produced for the PLAN, Chinese Coast Guard, and foreign sales. These shipyards have access to significant resources to contribute to China’s naval modernization. In addition to state budget funds, the Chinese shipbuilding companies have begun to enter capital markets to raise money through debt and equity sales. This will provide them with additional resources to close the gaps that still exist in some areas of military shipbuilding (Collins & Anderson, 2016).

While China has made major improvements in military shipbuilding overall, two areas are still significantly behind modern navies. The first is shipboard electronics, consisting of communications, radar, navigation, and fire control systems. The electronics industry in China has little overlap with the shipbuilding industry, meaning indigenous electronics are often not suitable for naval use. This requires shipbuilders to resort to foreign technology acquired through absorption. Often, the various systems they acquire are from different countries and use different standards. Integrating these differing systems is a difficult process and is often done after a vessel has been constructed and the systems installed. Until China makes additional investments in its domestic electronics industry, the capability of its vessels will be degraded (Ragland-Luce & Costello, 2016).

The other area in which Chinese shipbuilders are consistently behind their Western counterparts is power and propulsion systems. These systems are a weakness China has in other areas of its military as well, particularly its Air Force. The majority of the PLAN's surface vessels are powered by foreign diesel and gas turbine engines, mostly purchased from European companies. On the submarine side, China has been developing its own nuclear-powered submarines but relies on Russia for a lot of the required components. China still has much work to do in this area before its shipboard nuclear reactors come close to U.S. standards. As with electronics, integrating various foreign components is very complex when power and propulsion are concerned. Until the Chinese shipbuilding industry is able to produce conventional and nuclear-powered engines with similar performance to U.S. systems, PLAN vessels will not be able to compete with the USN in that area (Erickson, Ray, & Forte, 2016).

China's perception of the United States as a threat has been the driving force behind its recent naval improvement efforts. These improvements in turn affect the USN's strategy and planning. The USN has focused recent efforts on acquiring systems that will help it engage in a big power conflict as opposed to fighting non-state actors. Some of the capabilities that the USN has sought to increase through the JCIDS process, such as ballistic missile defense and antisubmarine warfare, can be directly related to PLAN advancements. For shipbuilding specifically, several recent acquisition actions have supported this effort. These include the decision to shift destroyer procurement away from the DDG-1000 class and into the DDG-51 Flight III as well as the restructuring of the Littoral Combat Ship (LCS) program into a more capable frigate-class of ship. With the United States conducting a strategic rebalance to Asia, U.S. shipbuilding decisions will continue to be influenced by a desire to counter Chinese advancements (O'Rourke, 2016).

D. CONCLUSION

This chapter explored literature that relates to acquisition efficiency, comparisons of acquisition systems between countries, and the PRC acquisition system. The first section identified the various metrics used by the United States to evaluate acquisition efficiency. Next, comparisons of the U.S. acquisition system to those of other countries were examined. Finally, the last section reviewed literature on the PRC acquisition process and focused on identifying characteristics of its system that affect acquisition efficiency.

In each of the three sections, various factors that can affect acquisition efficiency are identified with some overlap. Table 5 displays a list of each factor identified in this chapter and in which area of literature they are discussed. In the next chapter, the factors from this list that are most relevant to acquisition efficiency are identified and used to create a framework for analyzing a country's acquisition efficiency.

Table 5. Factors Identified in Literature that Affect Acquisition Efficiency

Acquisition Efficiency Factor	**U.S. Acquisition Efficiency**	**Comparisons of Acquisition Systems**	**The PRC Acquisition System**
Cost	X		X
Schedule	X		X
Performance	X		X
Acquisition Workforce	X	X	
Protests	X		
Competition	X	X	X
Contractor Audits	X		
Knowledge Points	X		
Budget Affordability	X		
Innovation	X		X
Productivity	X		
Bureaucracy	X		
Acquisition Processes	X	X	
Contracting Methods	X	X	X
Arms Exports		X	
Arms Imports		X	
Value for Money		X	
Political/Regulatory		X	X
Organizational Structure		X	
Collaboration		X	
Policy/Statutes		X	
Industrial Base	X		X
Leadership Support			X
Long-Term Planning			X
Compartmentalization			X
Contract Pricing			X
Corruption			X

IV. METHODOLOGY AND FRAMEWORK

This chapter begins by discussing the methodology that is used to form an acquisition efficiency framework. This includes how the efficiency factors will be selected as well as how metrics will be identified for those factors. In addition, the methodology used to analyze the data collected on USN and PLAN shipbuilding processes is discussed.

Next, a framework for analyzing shipbuilding acquisition efficiency between countries is developed. This framework is broad enough that it can be applied to any collection of two or more countries, not just the United States and China. The basis of this framework is a series of efficiency factors, each with a specific metric and scoring criteria used to determine which country is more capable with respect to that particular factor.

A. METHODOLOGY

This section discusses the methodology used throughout the remainder of this report. First, the methodology used to narrow down the list of efficiency factors is discussed. Next, the method used to determine the metrics and scoring criteria for the acquisition efficiency framework is reviewed. Finally, the method used to normalize and analyze data is identified.

1. Efficiency Factors

The first step in developing a framework for comparing acquisition efficiency among countries is to narrow down the list of efficiency factors that are to be included. Table 5 contains 27 individual efficiency factors that were identified during the literature review as having an impact on acquisition efficiency. In addition to these, there are also some factors that should be considered for inclusion that were not explicitly identified in the literature, which is mostly focused on the weapons development process. These include the resource allocation system, the requirements system, and O&S costs. The literature factors could cover these if approached from a certain way, but they are significant enough that they will be considered separate factors. This brings the total number of efficiency factors to 30, which is too high to develop a framework that is simple enough to be applied to any collection of countries. The more factors that are included, the harder it will be for a user of the framework to find reliable data on a country to complete the framework.

In order to ensure that the framework is not too complex to be applied broadly between countries, it is limited to a maximum of 10 factors. To meet this criteria, the original 30 factors are narrowed down to 10 or fewer using a three-step process. The first step consolidates any efficiency factors where the concepts are close enough that they can be grouped together. Next, the frequency in which a factor is referenced in literature is examined. If two or three components of the literature review mention a factor, it is likely to have a more significant impact on acquisition efficiency than a factor that is only mentioned once. A higher frequency in literature also indicates that a factor is studied more, meaning that data will be more readily available when researching a country. In the last step, after consolidating factors and looking at their frequency, professional judgement is used to determine which 10 factors to select for use in the framework. This is based on which factors will have the most impact on acquisition efficiency.

2. Metric Selection

Once the list of efficiency factors has been narrowed down to 10 or fewer, a method to judge these factors is developed. This takes the form of a simple metric for each factor that is designed to capture a country's performance in that particular area. Each metric is designed with simple criteria that score a country as good (four points), neutral (two points), or poor (zero points) in each factor. Once a country has been analyzed in each area, its scores can be added together to form an overall acquisition efficiency score. This method will allow users of the framework to review each country's score and determine which is more efficient overall, as well as which performs the best in each particular area. Comparing scores also makes the framework scalable by allowing users to examine any number of countries if that is what their own research requires. Users will also be able to use the framework to examine a country's overall acquisition system or just a particular sector, such as shipbuilding.

In order to select the metrics and scoring criteria to be applied to each efficiency factor, three simple standards are used. The first is that the metric must be relevant to the efficiency factor. The metric used should relate directly to the factor and how that factor relates to acquisition efficiency. The second standard is that the metric must be broad enough to be applied universally between countries. For example, a metric or scoring criterion related to the political environment cannot reference the role of civilian leadership because some countries are run by the military and lack a civilian leadership. Finally, the metrics and scoring criteria must be practical enough to be understood by individuals with only a basic knowledge of the acquisition process. It is assumed that this framework will be used by people both inside and outside the acquisition community and should be accessible to the largest possible audience without sacrificing its utility.

3. Data Analysis

After a framework has been developed along with the associated efficiency factors, metrics, and scoring criteria, that framework is demonstrated by applying it to the naval shipbuilding programs of the United States and China. In order to do this, data for each country that answers the required metrics is presented and a score provided for each of their shipbuilding programs. This score is specific to that country's acquisition efficiency in the area of shipbuilding only, but the framework itself could be used to examine the broader acquisition systems of both countries if different data were used. Depending on what the metric is looking for, two types of data are presented: qualitative and quantitative. The methodology used to analyze each of these data types varies.

When presenting qualitative data, information gathered through research on the U.S. and PRC acquisition systems that is relevant to a particular efficiency factor is referenced. A summary of qualitative data points that support the chosen score for a particular factor is presented to justify the score given. Unlike a quantitative analysis, a qualitative analysis is open to subjectivity based on the interpretation of the individual doing the scoring. In order to avoid this, the metrics selected for any factor that require qualitative data are very clear when identifying what that metric is looking for. Due to the nature of the efficiency factors and availability of data in some areas, it is not possible to avoid qualitative analysis, but every effort is made to limit the amount of subjectivity.

For qualitative analysis, data is presented in two ways. The first is through a broad summary of USN and PLAN shipbuilding efforts. For example, the data used for a particular metric may look at the total number of ships or total budget each country devotes to shipbuilding. The second method is a more detailed analysis to compare the acquisition programs for similar classes of ships. Five pairs of similar USN and PLAN ship classes are analyzed to compare factors such as cost and schedule. The capabilities of each platform are compared as well to determine which country's vessels are more capable independent of cost. When analyzing cost data, the monetary amounts are normalized to millions of Fiscal Year 2018 dollars (FY18$M) to allow for accurate comparisons. All PLAN cost data is already converted to dollars by the source. The Navy Center for Cost Analysis (NCCA) Joint Inflation Calculator (February 2018 version) is used to normalize dollar amounts to the same fiscal year. This is done using the Shipbuilding and Conversion, Navy appropriation. While this does not reflect the exact inflation rate for Chinese programs, it is the most relevant index that is available.

B. FRAMEWORK DEVELOPMENT

In this section, the framework used to compare acquisition efficiency between countries is developed. First, the list of efficiency factors identified in the previous chapter is narrowed down to the final list of factors that will be included in the framework. Then, a metric and scoring criteria for that metric is developed for each of these factors.

1. Factor Selection

The first step in narrowing down the list of efficiency factors is to consolidate those that are similar or are subcomponents of the same process. To accomplish this task, two or more factors that have a significant relationship are combined and an appropriate name is applied. Using this criteria, the following factors can be consolidated:

- The Requirements System and Long-Term Planning: Long-term planning is already a step in requirements systems, so it should be included in the requirements system factor.

- Contractor Audits, Contracting Methods, and Contract Pricing, and Protests: All are subcomponents of the contracting process and should be combined into a single factor that assesses contracting generally.

- The Acquisition Workforce, Bureaucracy, Compartmentalization, and Organizational Structure: These can all be combined into a single acquisition workforce factor because they all relate to how the acquisition workforce is designed and organized.

- The Resource Allocation System, Budget Affordability, and Value for Money: The method that a country uses to allocate resources already takes into account what its budget can afford and what it considers to be valuable, so these are all part of the resource allocation efficiency factor.

- Political/Regulatory, Leadership Support, and Policy/Statutes: All of these factors are related to the influence that government has on the acquisition process and can therefore be combined into a government efficiency factor.

- Arms Exports, Arms Imports, and Collaboration: All of these factors relate to how a country's acquisition system interacts with other countries' systems. They can therefore be combined into a foreign interaction efficiency factor.

- Competition and the Industrial Base: Competition can be included in the industrial base factor because it is a reflection of how much diversity exists in the industrial base.

After all combinations have been completed, the previous list of 30 factors is reduced to 16. This updated list can be found in Table 6. If two or more factors were consolidated into one, each area of literature that applied to one of those factors is checked for the new factor.

Table 6. Acquisition Efficiency Factors after Consolidation

Acquisition Efficiency Factor	**U.S. Acquisition Efficiency**	**Comparisons of Acquisition Systems**	**The PRC Acquisition System**
Cost	X		X
Schedule	X		X
Performance	X		X
Acquisition Workforce	X	X	X
Contracting	X	X	X
Knowledge Points	X		
Resource Allocation	X	X	
Innovation	X		X
Productivity	X		
Acquisition Processes	X	X	
Foreign Interaction		X	
Government		X	X
Industrial Base	X	X	X
Corruption			X
Requirements System			X
O&S Costs			

The next step to narrow down the number of efficiency factors to 10 or less is to analyze how many areas of the literature review they appear in. The results using these criteria are as follows:

- Three Areas of Literature: These are automatically included in the framework. This includes the acquisition workforce, contracting, and industrial base efficiency factors.

- Two Areas of Literature: These are carried over to the last step of the selection process to be selected based on professional judgement. This includes cost, schedule, performance, resource allocation, innovation, acquisition processes, and government.

- One or Zero Areas of Literature: These are eliminated unless there is a compelling reason to keep the factor. Using this criteria, knowledge points, productivity, foreign interaction, and corruption will not be included in the framework.

The requirements system and O&S costs are carried over to the last step of the process because they both relate directly to one of this paper's research questions. Table 7 lists all 12 remaining factors. Those that are automatically included are highlighted in bold.

Table 7. Acquisition Efficiency Factors after Frequency Analysis

Acquisition Efficiency Factor	**U.S. Acquisition Efficiency**	**Comparisons of Acquisition Systems**	**The PRC Acquisition System**
Cost	X		X
Schedule	X		X
Performance	X		X
Acquisition Workforce	**X**	**X**	**X**
Contracting	**X**	**X**	**X**
Resource Allocation	X	X	
Innovation	X		X
Acquisition Processes	X	X	
Government		X	X
Industrial Base	**X**	**X**	**X**
Requirements System			X
O&S Costs			

The remaining factors are selected using professional judgement. Cost, schedule, and performance are included because these are the traditional outcome measurements of how the weapons development process is performing (Rendon & Snider, 2008). Next, the resource allocation and requirement systems are also included because these are the other two main processes of an acquisition system. Innovation is included because how much a country can develop on its own without the technology of others is a direct reflection on the success of its R&D programs (Cheung, 2014a). Finally, O&S costs are included because they represent the final component of life-cycle costs to be addressed by this paper's research questions and are not reflected in any of the other factors.

After all selections have been made, acquisition processes and government are eliminated from the framework. While these are important, they both have an impact on many of the other selected factors so their effect is still reflected in the framework. Table 8 lists the final 10 factors that are included in the framework. In the next subsection, a metric and scoring criteria for each factor is developed.

Table 8. Final List of Acquisition Efficiency Factors

Acquisition Efficiency Factor	**U.S. Acquisition Efficiency**	**Comparisons of Acquisition Systems**	**The PRC Acquisition System**
Cost	X		X
Schedule	X		X
Performance	X		X
Acquisition Workforce	X	X	X
Contracting	X	X	X
Resource Allocation	X	X	
Innovation	X		X
Industrial Base	X	X	X
Requirements System			X
O&S Costs			

2. Metric and Scoring Criteria Selection

For each efficiency factor, the following list first states the metric that a user of the efficiency framework should use to assess that factor. It also includes some justification as to why each metric was chosen. The list then discusses the scoring criteria that a user of the framework should apply when grading each metric. This scoring criteria includes general guidelines the user should follow when assessing a factor as well as the specific numerical scores that should be applied based on the results of their assessment.

- Cost Metric: "Comparable systems of this country have the lowest cost to produce." Unlike some metrics of cost performance identified in research, this metric does not judge cost performance on the initial baseline of a program. This is due to the fact that baseline accuracy is widely varied.

Instead, this metric reflects the direct costs incurred by countries in the production of similar systems.

- Cost Scoring Criteria: This metric is assessed using quantitative data. The user of the framework should choose to assess either the acquisition system as a whole or a specific sector of it (in the case of this paper, shipbuilding is chosen). An assessment should be made of that sector as a whole as well as five comparable systems. A comparable system does not mean that they have the same capabilities, only that they are in the same class (e.g., destroyer). Capability will be assessed in the performance factor. Cost performance should be scored in the following ways:
    - Good: "Superior overall and in the majority of programs."
    - Neutral: "Superior overall or in the majority of programs."
    - Poor: "Neither superior overall nor in the majority of programs."
- Schedule Metric: "Comparable systems of this country are produced more quickly." As with cost performance, this metric is not based on a program's baseline. Instead, it compares the speed at which countries can produce comparable systems.
- Schedule Scoring Criteria: This metric is assessed using quantitative data. As with cost, an overall assessment should be made as well as one of five comparable systems. The five systems chosen should be the same ones used throughout the framework. Schedule performance should be scored in the following ways:
    - Good: "Superior overall and in the majority of programs."
    - Neutral: "Superior overall or in the majority of programs."
    - Poor: "Neither superior overall nor in the majority of programs."

- Performance Metric: “Comparable systems of this country have superior capabilities.” This metric will determine if systems of the same type are more capable, regardless of that system’s cost or schedule performance.

- Performance Scoring Criteria: This metric is assessed using quantitative and qualitative data. As with cost and schedule, both an overall assessment and one of the five comparable systems should be made. The overall assessment should reflect the general performance of that country’s systems, using the DoD benchmarks of operational effectiveness and suitability as a guide (DoD, 2016). When assessing comparable systems, the exact criteria used will vary greatly depending on what those systems are. For example, the criteria used to compare reconnaissance drones would be different than those used to compare aircraft carriers. The user should choose five attributes of a system that reflect its operational effectiveness and suitability. The system that performs better in the majority of attributes should be considered more capable. The performance of weapon systems should be scored in the following ways:

    - Good: “Superior overall and in the majority of programs.”

    - Neutral: “Superior overall or in the majority of programs.”

    - Poor: “Neither superior overall nor in the majority of programs.”

- Acquisition Workforce Metric: “This country has a well-trained and well-organized acquisition workforce.” This metric reflects the two aspects of the acquisition workforce discussed by Ching-Tsung (1997) as well as the other factors consolidated into the acquisition workforce efficiency factor.

- Acquisition Workforce Scoring Criteria: This metric is assessed using qualitative data. The user of this framework should assess whether the training given to members of a country’s acquisition workforce is adequate for them to do their jobs. They should also assess whether the organizational structure of the acquisition workforce is effective. The acquisition workforce of a country should be scored in the following ways:

  - Good: “Both well-trained and well-organized.”
  - Neutral: “Either well-trained or well-organized.”
  - Poor: “Neither well-trained nor well-organized.”

- Contracting Metric: “This country uses contracting methods that hold contractors accountable and incentivize them to meet objectives.” This metric reflects the various efficiency factors that were identified in literature and consolidated into the contracting factor. It assesses a contracting system’s ability to both penalize bad behavior by contractors and reward them for meeting objectives based on other efficiency factors such as cost, schedule, and performance (Cheung, 2017).

- Contracting Scoring Criteria: This metric is assessed using qualitative data. The user of this framework should assess the contracting mechanisms used by a country to determine whether they provide a means to hold contractors accountable for violating the terms of the contract and incentivize them for meeting contract goals. A country’s contracting methods should be scored in the following ways:

  - Good: “Both incentivize and hold contractors accountable.”
  - Neutral: “Either incentivize or hold contractors accountable.”
  - Poor: “Neither incentivize nor hold contractors accountable.”

- Resource Allocation Metric: “This country’s resource allocation system ensures programs are affordable and maximizes value for money.” This metric reflects the two efficiency factors that were consolidated into the resource allocation factor. For this metric, *affordable* means the current and future budgets of a country are capable of funding the program (OUSD[AT&L], 2014). *Maximizing value* means the system ensures that it gets the most it can out of available resources (Kausal et al., 1999).

- Resource Allocation Scoring Criteria: This metric is assessed using qualitative data. The user of this framework should assess the resource allocation system used by a country to determine whether it has mechanisms to take into account both affordability and maximum value. A country's resource allocation system should be scored in the following ways:
    - Good: "Both ensures affordability and maximizes value."
    - Neutral: "Either ensures affordability or maximizes value."
    - Poor: "Neither ensures affordability nor maximizes value."
- Innovation Metric: "This country has the R&D capability to produce a full range of modern military equipment." This metric reflects the level of advanced military systems a country is able to design domestically and is based on the three-tier system outlined by Bitzinger et al. (2014). Tier 1 countries have across-the-board R&D capabilities, Tier 2 have domestic R&D in some, but not all, areas, and Tier 3 have little to no domestic R&D (Bitzinger et al., 2014).
- Innovation Scoring Criteria: This metric is assessed using qualitative data. The user of this framework should assess the innovation system of a country and determine the range of military technologies that can be developed internally without the need for absorption. A country's ability to innovate should be scored in the following ways:
    - Good: "Capable of developing a full range of technologies."
    - Neutral: "Capable of developing some technologies."

- Poor: “Capable of developing little to no technologies.”

- Industrial Base Metric: “This country’s industrial base has the capacity and capability to meet the government’s requirements.” This metric assesses whether the industrial base of a country has the necessary skills to produce the types of systems the government requires. It also assesses whether the industrial base has enough capacity to produce these systems in the quantities that are required over a certain period of time.

- Industrial Base Scoring Criteria: This metric is assessed using both qualitative data. The user of this framework should assess the capability of the industrial base using data on the management and skills of the various sectors of the defense industry. Capacity should be assessed using data that reviews how much the country can produce over a given period of time. A country’s industrial base should be scored in the following ways:

  - Good: “Has both the capability and capacity to meet objectives.”

  - Neutral: “Has either the capability or capacity to meet objectives.”

  - Poor: “Has neither the capability nor capacity to meet objectives.”

- Requirements System Metric: “This country’s requirements system generates requirements that accurately meet the government’s objectives.” This metric assesses whether the requirements system of a country is successful in creating requirements that will fulfill the government’s strategic objectives. If the requirements generated do not meet this benchmark, then the requirements system is not operating efficiently.

- Industrial Base Scoring Criteria: This metric is assessed using qualitative data. The user of this framework should assess the processes and results of each country’s requirements system. A determination should be made whether the requirements documents produced by the system are influenced solely by the country’s strategic objectives or whether there are other factors. A country's requirements system should be scored in the following ways:

  - Good: "Generates only requirements that meet objectives."
  - Neutral: "Generates some requirements that meet objectives."
  - Poor: "Generates no requirements that meet objectives."

- O&S Costs Metric: "This country considers all O&S costs when developing a new weapon system." This metric assesses whether a country takes into account the full costs of operating and maintaining a system throughout its life cycle, rather than just development and production costs.

- O&S Costs Scoring Criteria: This metric is assessed using qualitative data. The user of this framework should assess whether O&S costs are analyzed by a country's acquisition system and whether those costs have any influence on the decision-making process. A country's ability to measure O&S costs should be scored in the following ways:

  - Good: "Considers all O&S costs when developing systems."
  - Neutral: "Considers some O&S costs when developing systems."
  - Poor: "Considers no O&S costs when developing systems."

With all metrics and scoring criteria identified, the acquisition efficiency framework is complete. The final framework can be found in Table 9. In the next chapter, this framework is demonstrated using data on the shipbuilding efforts of the USN and PLAN to determine which country demonstrates higher acquisition efficiency in that area.

Table 9. Acquisition Efficiency Framework

Acquisition Efficiency Factor	**United States**	**China**
Cost: Comparable systems of this country have the lowest cost to produce.	Cost performance on programs in this country is: **4 Points:** Superior overall and in the majority of programs. **2 Points:** Superior overall or in the majority of programs. **0 Points:** Neither superior overall nor in the majority of programs.	Cost performance on programs in this country is: **4 Points:** Superior overall and in the majority of programs. **2 Points:** Superior overall or in the majority of programs. **0 Points:** Neither superior overall nor in the majority of programs.
Schedule: Comparable systems of this country are produced more quickly.	Schedule performance on programs in this country is: **4 Points:** Superior overall and in the majority of programs. **2 Points:** Superior overall or in the majority of programs. **0 Points:** Neither superior overall nor in the majority of programs.	Schedule performance on programs in this country is: **4 Points:** Superior overall and in the majority of programs. **2 Points:** Superior overall or in the majority of programs. **0 Points:** Neither superior overall nor in the majority of programs.
Performance: Comparable systems of this country have superior capabilities.	The performance of weapon systems in this country is: **4 Points:** Superior overall and in the majority of programs. **2 Points:** Superior overall or in the majority of programs. **0 Points:** Neither superior overall nor in the majority of programs.	The performance of weapon systems in this country is: **4 Points:** Superior overall and in the majority of programs. **2 Points:** Superior overall or in the majority of programs. **0 Points:** Neither superior overall nor in the majority of programs.
Acquisition Workforce: This country has a well-trained and well-organized acquisition workforce.	The acquisition workforce of this country is: **4 Points:** Both well-trained and well-organized.	The acquisition workforce of this country is: **4 Points:** Both well-trained and well-organized.

Acquisition Efficiency Factor	United States	China
	2 Points: Either well-trained or well-organized. **0 Points:** Neither well-trained nor well-organized.	**2 Points:** Either well-trained or well-organized. **0 Points:** Neither well-trained nor well-organized.
Contracting: This country uses contracting methods that hold contractors accountable and incentivize them to meet objectives.	The contracting methods used by this country: **4 Points:** Both incentivize and hold contractors accountable. **2 Points:** Either incentivize or hold contractors accountable. **0 Points:** Neither incentivize nor hold contractors accountable.	The contracting methods used by this country: **4 Points:** Both incentivize and hold contractors accountable. **2 Points:** Either incentivize or hold contractors accountable. **0 Points:** Neither incentivize nor hold contractors accountable.
Resource Allocation: This country's resource allocation system ensures programs are affordable and maximizes value for money.	The resource allocation system of this country: **4 Points:** Both ensures affordability and maximizes value. **2 Points:** Either takes into account affordability or maximizes value. **0 Points:** Neither takes into account affordability nor maximizes value.	The resource allocation system of this country: **4 Points:** Both ensures affordability and maximizes value. **2 Points:** Either takes into account affordability or maximizes value. **0 Points:** Neither takes into account affordability nor maximizes value.
Innovation: This country has the R&D capability to produce a full range of modern military equipment.	This country's innovation system is: **4 Points:** Capable of developing a full range of technologies. **2 Points:** Capable of developing some technologies. **0 Points:** Capable of developing little to no technologies.	This country's innovation system is: **4 Points:** Capable of developing a full range of technologies. **2 Points:** Capable of developing some technologies. **0 Points:** Capable of developing little to no technologies.

Acquisition Efficiency Factor	**United States**	**China**
Industrial Base: This country's industrial base has the capacity and capability to meet the government's requirements.	The industrial base of this country: **4 Points:** Has both the capability and capacity to meet objectives. **2 Points:** Has either the capability or capacity to meet objectives. **0 Points:** Has neither the capability nor capacity to meet objectives.	The industrial base of this country: **4 Points:** Has both the capability and capacity to meet objectives. **2 Points:** Has either the capability or capacity to meet objectives. **0 Points:** Has neither the capability nor capacity to meet objectives.
Requirements System: This country's requirements system generates requirements that accurately meet the government's objectives.	The requirements system of this country: **4 Points:** Generates only requirements that meet objectives. **2 Points:** Generates some requirements that meet objectives. **0 Points:** Generates no requirements that meet objectives.	The requirements system of this country: **4 Points:** Generates only requirements that meet objectives. **2 Points:** Generates some requirements that meet objectives. **0 Points:** Generates no requirements that meet objectives.
O&S Costs: This country considers all O&S costs when developing a new weapon system.	This country's acquisition system: **4 Points:** Considers all O&S costs when developing systems. **2 Points:** Considers some O&S costs when developing systems. **0 Points:** Considers no O&S costs when developing systems.	This country's acquisition system: **4 Points:** Considers all O&S costs when developing systems. **2 Points:** Considers some O&S costs when developing systems. **0 Points:** Considers no O&S costs when developing systems.
TOTAL POINTS		

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V. DATA ANALYSIS

In this chapter, the acquisition efficiency framework is used to analyze the battle force shipbuilding programs of the USN and PLAN. This analysis is intended to both demonstrate the use of the framework and determine which country is more efficient in the acquisition of naval vessels. First, collected data for both countries is presented for each of the efficiency factors. Next, this data is analyzed using the framework's criteria to assign a score for both countries in each of the efficiency factors. Lastly, all the scores are presented and tallied using the format presented in Table 8.

A. COST FACTOR

In order to analyze the cost factor, an analysis is conducted on the total shipbuilding budget for each country from 2012–2016. This budget is then compared to the total number of battle force ships added to that country's fleet for each year. While shipbuilding budgets do support other programs, these programs all support the battle force. The country with the lowest dollar amount spent per battle force ship over the five years is scored as having better cost performance overall. Next, the costs of five comparable ship classes that represent a wide cross-section of ships are compared. These classes include a large surface combatant (destroyer), a small surface combatant (frigate or LCS), an amphibious transport dock, a nuclear-powered attack submarine, and an aircraft carrier. The country with the lowest cost per ship in a majority of programs is scored as having the better cost performance for individual programs.

1. United States

In the United States, 47 battle force ships were added to the USN fleet from 2012–2016. This translates to approximately $1.8 billion in FY18$ spent for every battle force ship. Table 10 shows the calculations used to develop this number.

Table 10. USN Overall Costs

	2012	2013	2014	2015	2016	Total
USN Battle Force Ships	11	11	8	8	9	47
USN Shipbuilding Budget (in Then-Year $M)	$15,138	$15,080	$15,231	$15,995	$18,704	$80,148
Then Year $ > 2018$ Inflation Factor	1.0891	1.0730	1.0572	1.0457	1.0333	
USN Shipbuilding Budget (in FY18$M)	$16,487	$16,181	$16,102	$16,726	$19,327	$84,823
Budget per Battle Force Ship (in FY18$M)	$1,499	$1,471	$2,013	$2,091	$2,147	$1,805
USN Average Battle Force Ships Per Year						9.4

Adapted from O'Rourke (2017c); Assistant Secretary of the Navy [Financial Management and Comptroller] (2018); NCCA (2018).

For individual USN programs, the following ship classes were chosen for analysis: the Arleigh Burke (DDG-51) class destroyer, the LCS (this analysis does not include a specific variant), the San Antonio (LPD-17) class amphibious transport dock, the Virginia (SSN-774) class attack submarine, and the Gerald R. Ford (CVN-78) class aircraft carrier. The most recent version of each of these programs is used when analyzing cost, schedule, and performance data. Table 11 shows the unit cost for each ship in FY$18M and the calculations used.

Table 11. USN Program Costs

	DDG-51	LCS	LPD-17	SSN-774	CVN-78
Unit Cost (in Then-Year $M)	$1,750	$568	$2,031	$2,766	$12,907
Then-Year	FY18	FY18	FY12	FY18	FY08
Inflation Factor	1.0000	1.0000	1.0891	1.0000	1.1571
Unit Cost (in FY18$M)	$1,750	$568	$2,212	$2,766	$14,935

Adapted from O'Rourke (2017b); O'Rourke (2017e); O'Rourke (2012); O'Rourke (2017f); O'Rourke (2017d); NCCA (2018).

2. China

In China, 83 battle force ships were added to the PLAN fleet from 2012–2016. This translates to approximately $343 million in FY18$ spent for every battle force ship. This data includes the Type 056 corvette, which is smaller than all USN battle force ships and relatively cheap to produce. China did not start operating corvettes until 2014, and since that time, at least 37 have entered service (O'Rourke, 2017a). Because there is no USN equivalent and the large quantity of corvettes skews the data, a sensitivity analysis is conducted that removes them. Using the revised numbers, the amount spent by the PLAN for every battle force ship is increased to approximately $558 million. Table 12 shows the calculations used to develop these numbers.

Table 12. PLAN Overall Costs

	2012	2013	2014	2015	2016	Total
PLAN Battle Force Ships	12	18	13	24	16	83
PLAN Battle Force Ships (without Type 056)	12	10	9	10	10	51
PLAN Shipbuilding Budget (in FY17$M)	$4,902	$4,828	$5,294	$6,686	$6,291	$28,002
2017$ > 2018$ Inflation Factor	1.016	1.016	1.016	1.016	1.016	
PLAN Shipbuilding Budget (in FY18$M)	$4,980	$4,906	$5,379	$6,793	$6,391	$28,450
Budget per Battle Force Ship (in FY18$M)	$415	$273	$414	$283	$399	$343
Budget per Battle Force Ship (without Type 056)	$415	$491	$598	$679	$639	$558
PLAN Average Battle Force Ships Per Year						16.6
PLAN Average Battle Force (without Type 056)						10.2

Adapted from Craig Caffrey, Jane's Defence Budgets (unpublished data); NCCA (2018).

For individual PLAN programs, the following ship classes were chosen for analysis: the Luyang III (Type 052D) class destroyer, the Jiangkai II (Type 054A) class frigate, the Yuzhao (Type 071) class amphibious transport dock, the Shang (Type 093A) class attack submarine, and the Shandong (Type 001A) class aircraft carrier. The Shandong is China's first indigenously built aircraft carrier. Its previous carrier, the Liaoning, is a retrofitted Soviet-era hull purchased from the Ukraine (O'Rourke, 2017a). The most recent version of each of these programs is used when analyzing cost, schedule, and performance data. Table 13 shows the unit cost for each ship in FY$18M and the calculations used.

Table 13. PLAN Program Costs

	Type 052D	Type 054A	Type 071	Type 093A	Type 001A
Unit Cost (in Then-Year $M)	$800	$375	$250	$900	$3,000
Then-Year	FY17	FY17	FY17	FY17	FY17
Inflation Factor	1.016	1.016	1.016	1.016	1.016
Unit Cost (in FY18$M)	$813	$381	$254	$914	$3,048

Adapted from Craig Caffrey, Jane's Defence Budgets (unpublished data); NCCA (2018).

3. Comparison

In the assessment of overall cost performance, both amounts per battle force ship calculated for China are significantly lower than the United States. This leads to China being scored as having better cost performance overall. As shown in Table 14, PLAN vessels cost less than their USN counterparts in all five individual classes. Therefore, China is scored as having better cost performance for individual programs as well.

Table 14. Comparison of Program Costs

Destroyer		Small Combatant		Amphibious		Attack Submarine		Aircraft Carrier	
DDG-51	052D	LCS	054A	LPD-17	71	SSN-774	093A	CVN-78	001A
$1,750	$813	$568	$381	$2,212	$254	$2,766	$914	$14,935	$3,048

B. SCHEDULE FACTOR

In order to analyze the schedule factor, an analysis is conducted on the total battle force ships added to each fleet from 2012–2016. The country with the highest average number of ships delivered per year is scored as having better schedule performance overall. Next, the construction schedules of the same five ship classes used for the cost factor are compared. The country that is able to construct ships (from when they are laid down to commissioned) faster in a majority of programs is scored as having the better schedule performance for individual programs. This analysis examines the most recently completed hulls in each ship class (up to 10) to capture each country's most current processes.

1. United States

Using the data in Table 9 to calculate the overall schedule factor, the USN is scored as adding an average of 9.4 battle force ships to its fleet each year from 2012–2016. For individual programs, Table 15 shows the average number of months to complete each class of ship and the data used to develop these numbers.

Table 15. USN Schedules. Adapted from Jane's by IHS Markit (2018).

DDG-51		**LCS**		**LPD-17**		**SSN-774**		**CVN-78**	
Hull #	Months	Hull #	Months	Hull #	Months	Hull #	Months	Hull #	Months
106	34	2	48	18	53	779	73	78	92
107	36	3	38	19	61	780	65		
108	29	4	51	20	66	781	67		
109	31	5	49	21	62	782	64		
110	33	6	38	22	60	783	67		
111	29	7	47	23	67	784	68		
112	28	8	39	24	59	785	65		
113	44	9	54	25	52	786	68		
114	39	10	38	26	56	787	71		
115	35	12	36	27	55	788	72		
AVG	34		44		59		68		92

2. China

Using the data in Table 10 to calculate the overall schedule factor, the PLAN is scored as adding an average of 16.6 battle force ships to its fleet each year from 2012–2016 when corvettes are included. When corvettes are excluded, this number drops to 10.2 ships per year. For individual programs, Table 16 shows the average number of months to complete each class of ship and the data used to develop these numbers.

Table 16. PLAN Schedules. Adapted from Jane's by IHS Markit (2018).

Type 052D		Type 054A		Type 071		Type 093A		Type 001A	
Hull #	Months	Hull #	Months	Hull #	Months	Hull #	Months	Hull #	Months
115	48	515	18	988	19	407	149	001A	60
117	43	531	19	989	27	408	84		
172	45	532	18	998	18	414	84		
173	61	536	24	999	28	415	72		
174	52	539	24						
175	48	576	32						
		577	22						
		578	24						
		579	26						
		598	19						
AVG	50		23		23		97		60

3. Comparison

In the assessment of overall schedule performance, both numbers of battle force ships added by the PLAN each year are higher than the 9.4 ships added by the USN. For this reason, China is scored as having the better schedule performance overall. As shown in Table 17, three out of five PLAN ship classes are constructed in less time than their USN counterparts. Therefore, China is scored as having better schedule performance for individual programs as well.

Table 17. Comparison of Program Schedules

Destroyer		Small Combatant		Amphibious		Attack Submarine		Aircraft Carrier	
DDG-51	052D	LCS	054A	LPD-17	071	SSN-774	093A	CVN-78	001A
34	50	44	23	59	23	68	97	92	60

C. PERFORMANCE FACTOR

In order to analyze the performance factor, an overall analysis is conducted on suitability and effectiveness of each country's naval force. The country that is assessed as being more effective is scored as having better performance overall. Next, five characteristics of each of the ship classes are compared. The country with the majority of superior classes is scored as having better performance for individual programs. The five characteristics chosen include top speed, crew complement, displacement, primary weapon, and primary sensor. Each of these factors represent a different aspect of the ship and influence its performance as well as cost and schedule to produce.

1. United States

Overall, the United States is widely considered to have a very effective naval force. According to the DoD (2016), the majority of all weapon systems meet or exceed their suitability and effectiveness requirements. The United States is consistently at least one generation ahead of China in the fields of technology and innovation (Cheung, 2017). In addition, it is widely considered the only country capable of domestically producing a full array of modern naval vessels (Bitzinger et al., 2014). For individual programs, Table 18 shows the characteristics of each of the five USN ship classes that are analyzed. For the LCS, the variant with the least capable metric is included in the table.

Table 18. Characteristics of USN Programs. Adapted from Jane's by IHS Markit (2018).

Program	Top Speed	Crew	Displacement	Primary Weapon	Primary Sensor
DDG-51	31 KT	300	9276 LT	96 VLS Cells	SPY-1D
LCS	40 KT	40	3137 LT	21 RIM Missiles	SPS-77
LPD-17	22 KT	400	24506 LT	~700 Marines	SPS-48E
SSN-774	34 KT	180	7800 LT	12 VLS Tubes	BQQ-10 Sonar
CVN-78	30 KT	4550	100000 LT	~75 Aircraft	SPY-3

2. China

China has an effective naval force in some areas but lags behind the United States in others. PLAN ship components such as propulsion, power, and electronics systems do not meet the same standards as the USN (Erickson et al., 2016; Ragland-Luce & Costello, 2016). In addition, the PLAN has only recently begun an aircraft carrier program, which is the backbone of the USN. This capability is still in the testing and training phase and has not been proven in combat operations (O'Rourke, 2017a). For individual programs, Table 19 shows the characteristics of each of the five PLAN ship classes that are analyzed.

Table 19. Characteristics of PLAN Programs. Adapted from Jane's by IHS Markit (2018).

Program	Top Speed	Crew	Displacement	Primary Weapon	Primary Sensor
Type 052D	30 KT	320	7381 LT	64 VLS Cells	Type 346
Type 054A	27 KT	165	3900 LT	8 C-802 Missiles	Fregat MAE-3
Type 071	25 KT	180	19541 LT	~500 Marines	Type 347G
Type 093A	30 KT	100	5999 LT	6 C801A Missiles	Active Sonar
Type 001A	30 KT	2826	58500 LT	~24 Aircraft	Type 346

3. Comparison

In the assessment of overall ship performance, the USN is ahead of the PLAN technologically, has more effective ship components, and has a proven aircraft carrier capability. This leads to the United States being scored as having the better ship performance overall. As shown in Table 20, four out of five USN ship classes score better in performance characteristics than their PLAN counterparts. Therefore, the United States is scored as having better ship performance for individual programs as well.

Table 20. Comparison of Program Characteristics

Class	Program	Top Speed	Crew	Displacement	Primary Weapon	Primary Sensor
Destroyer	**DDG-51**	31 KT	300	9276 LT	96 VLS Cells	SPY-1D
	Type 052D	30 KT	320	7381 LT	64 VLS Cells	Type 346
Small Combatant	**LCS**	40 KT	40	3137 LT	21 RIM Missiles	SPS-77
	Type 054A	27 KT	165	3900 LT	8 C-802 Missiles	Fregat MAE-3
Amphibious	**LPD-17**	22 KT	400	24506 LT	~700 Marines	SPS-48E
	Type 071	25 KT	180	19541 LT	~500 Marines	Type 347G
Attack Submarine	**SSN-774**	34 KT	180	7800 LT	12 VLS Tubes	BQQ-10 Sonar
	Type 093A	30 KT	100	5999 LT	6 C801A Missiles	Active Sonar
Aircraft Carrier	**CVN-78**	30 KT	4550	100000 LT	~75 Aircraft	SPY-3
	Type 001A	30 KT	2826	58500 LT	~24 Aircraft	Type 346

D. ACQUISITION WORKFORCE FACTOR

In order to score the acquisition workforce factor, an analysis is conducted on the training that each country's acquisition workforce receives. The focus of this is on the adequacy of the training compared to the job responsibilities that members of the workforce are expected to carry out. Next, a separate analysis is conducted on the organization of each country's acquisition workforce, focusing on their levels of bureaucracy and compartmentalization.

1. United States

In the United States, the acquisition workforce is trained through the Defense Acquisition University (DAU), which was created to ensure that the workforce meets professional standards. Each member of the acquisition workforce specializes in a specific job function such as contracting, project management, or financial management. The curriculum of DAU is structured to support these functions, and employees can earn progressively more advanced certifications in their career fields as they gain experience and training (Ching-Tsung, 1997). This system ensures that people are trained at the right level to do the jobs that they are assigned. Due to this training method, the United States is scored as having a well-trained acquisition workforce.

The majority of the U.S. acquisition workforce that supports shipbuilding programs is centrally located at the Naval Sea Systems Command (NAVSEA). According to its website, NAVSEA's mission is to "design, build, deliver, and maintain ships and systems on time and on cost for the United States Navy" (NAVSEA, 2018). To accomplish this mission, NAVSEA has workforce members in each specialty working under one roof. This enables employees with differing job functions to work together through the formation of integrated product teams (IPTs) at the program level. IPTs ensure that the right people are working together on a project to increase efficiency (Kausal et al., 1999). For these reasons, the United States is scored as having a well-organized acquisition workforce.

2. China

The acquisition workforce in China is centered on the MRO system. Like the workforce in the United States, they receive varying levels of training depending on their position and seniority. This training is inadequate, however. Employees lack the technical expertise to oversee projects for which they are responsible and are often trained in multiple job functions without ever specializing in any of them. China has implemented reforms to improve this, but it will take some time to determine whether these reforms are effective. Until that time, China is scored as having an inadequate acquisition workforce training system (Puska, Geary, & McReynolds, 2014).

For the organization of China's acquisition workforce, the PLAN maintains its own MROs responsible for overseeing shipbuilding efforts. The PLAN MRO structure has multiple levels of hierarchy based on the location of shipyard facilities. Each person's responsibilities in this hierarchy are unclear, however, as employees are often assigned overlapping duties (Puska, Geary, & McReynolds, 2014). In addition, there is a significant amount of compartmentalization. Units responsible for different phases of the acquisition process, such as R&D and production, are stove-piped into their own individual areas. There is no formal IPT structure and interaction is conducted on an informal basis (Cheung, 2017). Because of these deficiencies, the organization of the acquisition workforce in China is scored as inadequate.

E. CONTRACTING FACTOR

To score the contracting factor, an analysis is conducted on the contracting methods used by that country in the acquisition of naval vessels. The focus of this analysis is on how well each country's contracting methods hold contractors responsible for their obligations and incentivize them to meet cost, schedule, and performance objectives.

1. United States

For large complex systems such as ships, the USN usually enters into some form of cost-based contract in which the government assumes some risk. In order to hold contractors accountable and incentivize them to meet targets, contractor profit is often tied to pre-determined cost, schedule, and performance levels. If the targets are met, the contractor may receive a higher profit percentage or other type of award. This method is very effective because contractors are for-profit companies, and recording a higher profit is their primary goal. The government can also terminate contracts for cause when the contractor fails to meet its obligations, causing them to lose money and potentially future business (Rendon, 2008). Because of these methods, the United States is scored as able to incentivize contractors and hold them accountable.

2. China

The contracting methods available in China are very limited when compared to the United States. When purchasing ships and other complex systems, contracts can sometimes be as short as one or two pages. They do not define a contractor's obligations or cost, schedule, and performance objectives. For these reasons, it is not possible to hold a contractor accountable. In addition, China does not make use of incentive-based awards to encourage contractors to keep costs down or take risks. Instead, most contracts are written to reimburse contractors their costs, plus a 5% profit. This encourages contractors to let their costs rise in order to make more profit (Cheung, 2017). For these reasons, China's contracting methods are scored as ineffective at both incentivizing and holding contractors accountable.

F. RESOURCE ALLOCATION FACTOR

To score the resource allocation factor, an analysis is conducted on the resource allocation and budgeting system used by each country. Each one is analyzed with respect to how it incorporates affordability into its budget decisions. In addition, each system is assessed to ensure that it maximizes value for money.

1. United States

In the area of shipbuilding, the USN considers affordability when making budget requests to Congress. These requests take into consideration the fact that resources are not unlimited and must be balanced to meet objectives. They also consider affordability when drafting the 30-year shipbuilding plan by taking into account estimated future costs and funding levels. Overall, the USN works to ensure that its plans will be affordable throughout their execution. In regards to maximizing value, the USN does not get the most out of its resource allocation system due to the effect of CRs. These cause delays in new program starts, making it difficult to execute all funding on time, and money is often returned to the treasury at the end of the fiscal year (O'Rourke, 2017c). For these reasons, the resource allocation system in the United States is scored as effective at ensuring affordability and ineffective at maximizing value.

2. China

The official Chinese resource allocation system does not provide its units with the adequate funding needed to execute their responsibilities. When programs go over budget, the balance is not provided by the SPC. Services such as the PLAN are required to seek extrabudgetary resources from various sources to make their programs affordable. This has led to the SPC having no mechanism to ensure affordability because it can force the services to seek money elsewhere. This outside money also has an influence on China's ability to maximize value. Without a single process overseeing the defense budget, units and services are free to spend without any oversight. This increases the risk that money will be used on pet projects that lack value (Crane et al., 2005). China is therefore scored as ineffective at both ensuring affordability and maximizing value.

G. INNOVATION FACTOR

To score the innovation factor, an analysis is conducted on each country's ability to develop the full range of systems required for naval vessels. Each country is analyzed to determine if it has the technical expertise to develop components on its own or if it requires assistance from other countries.

1. United States

The United States is the most capable of any country in the area of defense innovation. With a large R&D budget and technical expertise in all areas, the United States is considered the only country to reach Tier 1a status. This means that it has the capacity for across-the-board development without having to collaborate with other countries

(Bitzinger et al., 2014). This carries over to the shipbuilding industry, where the USN leads the world in technologies such as nuclear propulsion and catapult launching systems for aircraft. These advancements represent the benchmarks for what other countries desire for their naval forces. Instead of developing their own unique naval technologies, other countries want to match the innovations of the United States (Erickson et al., 2016). For these reasons, the United States is scored as capable of developing the full range of technologies needed for the production of naval vessels.

2. China

While China does produce a full range of defense systems, many of the technologies in these systems are from external sources. This gives China the status of a Tier 2c country, meaning that it cannot indigenously produce complex weapons (Bitzinger et al., 2014). This carries over to the production of naval vessels. While China does have the ability to produce a variety of platforms, it lacks the ability to develop many of the required components. As discussed above, China lags behind its peers in shipboard electronics and power and propulsion systems (Erickson et al., 2016; Ragland-Luce & Costello, 2016). This has required China to rely on the absorption of foreign technology. In the area of shipbuilding, the primary source of naval technology has been Russia (Cheung, 2017). Because of these shortfalls, China is scored as capable of developing some, but not all technologies needed for naval vessels.

H. INDUSTRIAL BASE FACTOR

To score the industrial base factor, an analysis is conducted on each country's shipbuilding industry to determine whether it has the capacity to meet the military's requirements. Next, the capability of each is analyzed to determine whether it is able to construct advanced warships.

1. United States

The USN currently relies on seven new construction shipyards. While these shipyards have the capacity to meet the Navy's 30-year shipbuilding plan, that is only because the plan itself takes this constraint into consideration. In reality, the USN's capacity to produce new ships lags behind that of its peers. If there were a sudden need to increase the 30-year shipbuilding plan, it is unknown how long this would take or how much it would cost (DON, 2018). In regards to capability, the U.S. workforce is technically proficient and capable of producing a full range of naval vessels and technologies. This technical proficiency does take time to develop, which contributes to the cost and time it takes to expand capacity. In the past, unpredictable demand caused the industry to lose capability when people left the workforce. The current shipbuilding plan addresses this by ramping up production in a way that will develop skills and maintain proficiency (DON, 2018). Because of these reasons, the U.S. industrial base is rated as having the capability but not having the capacity to meet its objectives.

2. China

The Chinese shipbuilding industry, both civilian and military, is the largest in the world. Like the United States, China has seven major shipyards that it uses for military construction. Unlike the United States, however, these shipyards have capacity beyond what the PLAN requires. This allows the Chinese to construct naval vessels to sell to other countries in addition to what they need for themselves (Collins & Anderson, 2016). When capability is assessed, the Chinese industrial base is lacking when compared to its peers. It does not have the ability to construct many of the key systems needed in naval vessels, even when a design is available. This has necessitated the purchase of completed components from other countries. Once they are purchased, the industrial base is often unable to integrate them properly, causing delays in production and degraded capabilities. For these reasons, the Chinese industrial base is rated as having the capacity but not the capability to meet its objectives.

I. REQUIREMENTS SYSTEM FACTOR

To analyze the requirements system factor, the process that each country uses to generate requirements for naval vessels is analyzed. This analysis focuses on whether the finalized requirements documents meet the strategic objectives of that country.

1. United States

Overall, the requirements system of the United States is effective in translating national security objectives into requirements. In the acquisition of naval vessels, the USN follows the same top-down process used by other services. Broad national security objectives are translated into a series of key performance parameters (KPPs) that lay out the operational needs of a new ship. The formalized, non-political nature of the JCIDS system ensures that KPPs generally reflect the actual requirements needed (Snider, 2008). While Congress may change the quantities of a particular ship for political reasons, this is a budgeting issue rather than a requirements one (O'Rourke, 2017e). Due to these reasons, the United States is scored as generating requirements that only meet its objectives.

2. China

Like the United States, the Chinese requirements system takes long-range planning and strategic documents into account when deciding which programs should be developed. The process for how the final decision is made is somewhat ambiguous, however. Once a list of desired capabilities needed to meet the country's strategic objectives is drawn up by the military, a special committee meets to determine which projects will go forward. This committee is dominated by CCP members and the decisions are often political in nature. This process makes it likely that some systems will be approved for solely political reasons and not necessarily to meet a strategic objective (Puska, Shraberg et al., 2014). For these reasons, the Chinese requirements system is scored as generating some requirements that accurately meet objectives.

J. O&S COSTS FACTOR

To score the O&S costs factor, the acquisition system of each country is analyzed to determine how much it takes O&S costs into account during decision making. A determination is made if O&S costs are considered when calculating the total life-cycle costs of a new naval vessel, or if only development and production costs are considered.

1. United States

In the United States, O&S costs are a major consideration in all programs and can reach as high as 70% of the total life-cycle costs of a system. Throughout the weapons development process, cost estimates are conducted in order to advance to the next milestone. These estimates are for total life-cycle costs, including R&D, procurement, and O&S (Schwartz, 2014). In addition to including O&S in cost estimates, each program office is responsible for that system throughout its life cycle. There is no handing off of a system's support responsibilities to another organization once it is purchased. This ensures that those who are responsible for developing and procuring a system also take into account its support (Kausal et al., 1999). For these reasons, the United States is scored as considering all O&S costs when developing systems.

2. China

Unlike the United States, which uses the same program office throughout a system's life cycle, different organizations are responsible for R&D, procurement, and O&S in China (Cheung, 2017). This fragmentation has led to each organization only concentrating on the costs that apply to them and not factoring in a program's entire life cycle. In the PLAN, the NED is responsible for developing and procuring warships, while the operational forces are responsible for O&S costs (Pollpeter & Stokes, 2016). Chinese officials do recognize that O&S costs are important, however. They have blamed problems such as equipment not meeting its expected life on failure to properly maintain it throughout its life cycle. This has led China to begin considering O&S costs in its life-cycle management system (Puska, Shraberg et al., 2014). For these reasons, China is scored as considering some O&S costs when developing systems.

3. Conclusion

This chapter presented data on the USN and PLAN for each of the 10 factors included in the acquisition efficiency framework. That data was then used to score both countries' naval shipbuilding systems in each factor. A summary of all scores applied to the acquisition efficiency framework is included in Table 21. The United States received a final score of 28, while the Chinese received a final score of 16. This indicates that the

United States is more efficient in the acquisition of naval battle force ships than China. In the next chapter, this result is analyzed to provide answers to this paper's research questions.

Table 21. Summary of USN and PLAN Acquisition Efficiency

Acquisition Efficiency Factor	United States	China
Cost: Comparable systems of this country have the lowest cost to produce.	Cost performance on programs in this country is: **0 Points:** Neither superior overall nor in the majority of programs.	Cost performance on programs in this country is: **4 Points:** Superior overall and in the majority of programs.
Schedule: Comparable systems of this country are produced more quickly.	Schedule performance on programs in this country is: **0 Points:** Neither superior overall nor in the majority of programs.	Schedule performance on programs in this country is: **4 Points:** Superior overall and in the majority of programs.
Performance: Comparable systems of this country have superior capabilities.	The performance of weapon systems in this country is: **4 Points:** Superior overall and in the majority of programs.	The performance of weapon systems in this country is: **0 Points:** Neither superior overall nor in the majority of programs.
Acquisition Workforce: This country has a well-trained and well-organized acquisition workforce.	The acquisition workforce of this country is: **4 Points:** Both well-trained and well-organized.	The acquisition workforce of this country is: **0 Points:** Neither well-trained nor well-organized.
Contracting: This country uses contracting methods that hold contractors accountable and incentivize them to meet objectives.	The contracting methods used by this country: **4 Points:** Both incentivize and hold contractors accountable.	The contracting methods used by this country: **0 Points:** Neither incentivize nor hold contractors accountable.
Resource Allocation: This country's resource allocation system ensures programs are affordable and maximizes value for money.	The resource allocation system of this country: **2 Points:** Either ensures affordability or maximizes value.	The resource allocation system of this country: **0 Points:** Neither ensures affordability nor maximizes value.

Acquisition Efficiency Factor	**United States**	**China**
Innovation: This country has the R&D capability to produce a full range of modern military equipment.	This country's innovation system is: **4 Points:** Capable of developing a full range of technologies.	This country's innovation system is: **2 Points:** Capable of developing some technologies.
Industrial Base: This country's industrial base has the capacity and capability to meet the government's requirements.	The industrial base of this country: **2 Points:** Has either the capability or capacity to meet objectives.	The industrial base of this country: **2 Points:** Has either the capability or capacity to meet objectives.
Requirements System: This country's requirements system generates requirements that accurately meet the government's objectives.	The requirements system of this country: **4 Points:** Generates only requirements that meet objectives.	The requirements system of this country: **2 Points:** Generates some requirements that meet objectives.
O&S Costs: This country considers all O&S costs when developing a new weapon system.	This country's acquisition system: **4 Points:** Considers all O&S costs when developing systems.	This country's acquisition system: **2 Points:** Considers some O&S costs when developing systems.
TOTAL POINTS	**28**	**16**

VI. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

The goal of this research was to develop a framework that can be used to compare the acquisition efficiency of different countries and then apply that framework to the naval shipbuilding programs of the USN and the PLAN. Specifically, this paper sought to answer the following questions outlined in Chapter I.

1. Primary Research Question

- How can the differences in efficiencies of the acquisition systems for naval vessels in the United States and China be identified and measured?

This can be accomplished through the acquisition efficiency framework developed in this paper. This framework consists of 10 efficiency factors that can be applied to different countries' acquisition programs or portions of their acquisition programs, such as shipbuilding. These factors include cost, schedule, performance, the acquisition workforce, contracting, the resource allocation system, innovation, the industrial base, the requirements system, and O&S costs.

When using the framework, the differences in efficiencies are identified by comparing the scores for both countries and seeing which country is superior in each efficiency factor. These scores are measured by using a combination of quantitative and qualitative data, depending on the factor. Table 21 shows the final results of this research question, with scores given for each country overall, as well as in each factor. The United States is more efficient than China overall and in seven of the 10 factors. China is more efficient than the United States in the areas of cost and schedule performance. Finally, both countries scored the same in the industrial base factor.

2. Secondary Research Questions

- What are the key acquisition processes used by the United States and China?

Both the United States and China use three key processes in the acquisition of defense systems. These include a requirements generation system, a resource allocation system, and a weapons development system (Brown, 2010). Table 1 provides a side-by-side comparison of the three processes used in each country. While each country performs similar tasks in these systems, there are some key differences between the two. The United States uses a capability-based requirements system, while China uses a threat-based one (Sorenson, 2009). The U.S. resource allocation process is a formal system, while the Chinese use an informal process that relies on extrabudgetary revenue to meet requirements (Crane et al., 2005). Finally, the U.S. weapons development process consists of five life-cycle phases, while China uses seven (Puska, Shraberg et al., 2014).

- Can the total life-cycle costs (development, procurement, and operations and support [O&S] costs) for similar acquisitions be compared?

It is likely that all three types of life-cycle costs could be compared between the United States and a country with a similar system such as the United Kingdom. With the exception of procurement costs, this is not the case for the United States and China. China's reliance on absorption for new technologies, as opposed to the United States' reliance on investment in R&D, makes a direct comparison of the two figures an inaccurate representation. Generally, the United States spends much more than China because China is not developing its own technologies (Cheung, 2017).

In regards to procurement, costs can be compared between similar acquisitions. This paper did so by analyzing the procurement costs of five similar naval ship classes. Table 14 provides a summary of the results. For each of these ship classes, China performed better than the United States. For O&S costs, there is not any available quantitative data for Chinese systems to compare to the United States. This is due in part to the fact that China does not consider all O&S costs when making acquisition decisions. Once a system is produced and fielded, it is no longer the responsibility of the acquisition system to fund and maintain (Puska, Shraberg et al., 2014).

- What are the differences in acquisition performance (i.e., fielded capabilities) between the United States and China?

Overall, the U.S. acquisition system has better fielded more capable naval vessels than China. This paper answered this question by comparing five ship classes in five areas of performance. Table 20 provides a summary of the results. In four of the five ship classes, the United States demonstrated better capabilities.

B. IMPLICATIONS AND RECOMMENDATIONS

The results of this research show that the United States is overall more efficient than China in the acquisition of naval vessels. While this is good news for the USN, there are some reasons to be concerned. China, despite being outperformed by the United States in most areas of acquisition efficiency, is still able to produce naval vessels faster and at a lower cost. This has allowed the PLAN to close the gap in the number of ships that exists between it and the USN. If this trend continues, the PLAN will surpass the USN in size sometime in the 2030s (Erickson, 2016). In addition, China has been working to reform its acquisition system and close the gap between itself and the United States in the other areas of acquisition efficiency (Cheung, 2017). If it is successful in this effort, the PLAN may be able to surpass the USN even earlier. To maintain its strategic advantage and prevent the PLAN from overtaking it, the USN should consider the following recommendations:

1. Accelerated Acquisition: The United States already has a process for the rapid acquisition of a needed defense system (DoD, 2017). The DoD and USN should examine this process and determine whether any of the best practices used in it can be implemented across the acquisition system as a whole. This would help increase schedule performance.

2. Contracting Methods: The USN is already using MYP and BBC for some shipbuilding efforts and has seen costs decrease by as much as 10% (*Acquisition Efficiency*, 2015). Instead of being the exception, these processes should be implemented wherever possible to reduce overall shipbuilding costs per ship.

3. Increase Capacity: Currently, the USN relies on seven new construction shipyards for all of its shipbuilding needs (DON, 2018). To grow its

industrial base and increase capacity, the USN should consider providing incentives and training to shipyards that do not currently do military construction. Even the addition of only one or two more shipyards could greatly increase capacity and lower costs as a result of the increased level of competition in the industry.

4. Corvette Class Vessel: One of the reasons that the PLAN has been able to close the gap in ship numbers with the USN is the addition of a corvette. Smaller than an LCS and larger than a patrol ship, the USN does not have any equivalent class of ship (Jane's by IHS Markit, 2018). An analysis should be conducted to determine whether such a vessel would be beneficial for the USN.

5. Use of Absorption: The use of absorption by the Chinese is perhaps the biggest factor in their better cost and schedule performance (Cheung, 2017). R&D requires a significant investment in time and money. In order to close this gap, the USN should consider using foreign or commercial technologies whenever feasible. In addition, collaboration with allies on a new class of ship such as the corvette could help to shorten the schedule and reduce development costs (Kausal et al., 1999).

C. FUTURE RESEARCH

This research was limited to comparing the acquisition efficiency of naval vessels between the United States and China. The framework that was developed in this paper can be used to support a variety of other research topics and approaches, however. Some suggestions for future research related to this topic include the following:

1. Classified Data: The data on USN and PLAN shipbuilding efforts used in this research is all open source and unclassified. An organization with access to classified data on these programs should consider doing its own analysis on Chinese shipbuilding efforts using the same framework. This

would increase the accuracy of the results as well as confirm the validity of the open source data.

2. Normalize Cost and Schedule Data with Performance Metrics: This paper looked at these factors separately, but integrating them together could provide useful information. For example, developing metrics such as the time it takes to construct a ship based on crew size or tonnage, as well as the cost of a ship based on the performance of its weapons or engines, would allow for different comparisons of efficiency.

3. Different Countries or Sectors: The use of this framework should be further demonstrated by analyzing the shipbuilding programs of other countries. In addition, China and others should be compared to the United States in sectors other than shipbuilding. Using this framework in a variety of applications will help to either validate its accuracy or identify areas where the framework could be adjusted.

4. Recommendations: Each of the recommendations presented in the previous section has the potential to increase the acquisition efficiency of the USN. Before implementing any of them, research such as a cost-benefit analysis should be conducted to determine their effects.

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