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AN EXPLORATORY ANALYSIS OF THE U.S. SYSTEM OF MAJOR DEFENSE ACQUISITION UTILIZING THE CLIOS PROCESS

by

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September 2009

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13. ABSTRACT (maximum 200 words)

For decades, the United States' major defense acquisition system has been under scrutiny and undergone much reform. Groups have researched the issues, publishing hundreds of reports identifying various problems and solutions. Yet, many major weapon systems continue to be well over budget and schedule. Major weapon systems are increasing in size, scope, and complexity. Technology is rapidly changing. Customer expectations are rising. Societal concerns, such as workforce and economic development, are playing a bigger role. Politics are rampant in this system. This system qualifies as a CLIOS system—Complex, Large-scale, Interconnected, Open, and Sociotechnical in nature.

This thesis explored and analyzed the decades of research concerning U.S. major weapon systems acquisitions and applied the CLIOS Process. Of the three stages within the CLIOS Process, this research applied the Representation Stage to the U.S. major defense acquisition system. The observations afforded from the analysis were: (1) long-term decisions are made with short-term information and (2) multiple stakeholders and decision makers facilitate little accountability. Three strategic alternatives were identified: (1) create an Integrated Process Team to make joint long-term decisions, (2) mandate a Federal Systems Engineering organization, and (3) create a hybrid between the first two for instilling accountability at all levels.

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AN EXPLORATORY ANALYSIS OF THE U.S. SYSTEM OF MAJOR DEFENSE ACQUISITION UTILIZING THE CLIOS PROCESS

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This thesis explored and analyzed the decades of research concerning U.S. major weapon systems acquisitions and applied the CLIOS Process. Of the three stages within the CLIOS Process, this research applied the Representation Stage to the U.S. major defense acquisition system. The observations afforded from the analysis were: (1) long-term decisions are made with short-term information and (2) multiple stakeholders and decision makers facilitate little accountability. Three strategic alternatives were identified: (1) create an Integrated Process Team to make joint long-term decisions, (2) mandate a Federal Systems Engineering organization, and (3) create a hybrid between the first two for instilling accountability at all levels.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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EXECUTIVE SUMMARY

For decades, the United States' major defense acquisition system has been under scrutiny and undergone much reform. Numerous groups have researched the issues, publishing hundreds of reports identifying various problems and solutions. Yet, many major weapon systems continue to be well over budget and schedule.

The U.S. major defense acquisition system is increasing in size, scope, and complexity each year. Technology associated with major weapon systems is rapidly changing. Customer expectations are rising. Societal concerns, such as workforce and economic development, are playing an increasingly bigger role. Politics continue to play a part in this system. This system certainly qualifies as a CLIOS system—Complex, Large-scale, Interconnected, Open, and Sociotechnical in nature.

This thesis explored and analyzed the decades of research concerning U.S. major weapon systems acquisitions. The research introduced the CLIOS Process developed by MIT to analyze and study complex systems. The basic structure of the CLIOS Process is three stages encompassing 12 steps. The three stages include (1) Representation; (2) Design, Evaluation, and Selection; and (3) Implementation.

Of the three stages within the CLIOS Process, this research applied the Representation stage to the U.S. major defense acquisition system. This exploratory approach described the system as a whole, identified subsystems, and described the components and links among the subsystems and major actor groups. Despite continuing with the CLIOS Process, initial analysis was conducted based on the observations of Stage 1. This resulted in two observations: (1) Long-term decisions made on short-term information and (2) Independent working leads to lesser accountability. Three strategic alternatives were identified: (1) form an Integrated Process Team with Congress, JCIDS and the Defense Acquisition System to jointly consider both near and far-term economic conditions and security threats before new long-term defense programs were approved and funded; (2) form a mandated Federal Systems Engineering organization equally accountable to both Congress and DoD to consider economic and threat conditions,

analyze technological maturity, and make independent cost estimates as inputs to new defense system acquisition decisions; and (3) create a hybrid of the two previous solutions to implement accountability at all levels of the acquisition to all major actor groups. Of course, challenges to implementation will exist. However, continuing with the CLIOS Process will facilitate in refining the strategic alternatives, as well as implementing them.

Further research should be conducted on the U.S. major defense acquisition system using the CLIOS Process. The remaining stages of the CLIOS Process, especially the iterative aspects of the process, should be applied to the U.S. major defense acquisition system.

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I want to thank my classmates in Cohort 8. We have shared many experiences these past two years. Thank you for the memories.

Brian—the love of my life! I dedicate this to you. “Thanks” is not enough.

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I. INTRODUCTION

A. BACKGROUND

For more than a half century, issues surrounding the United States' major weapons system acquisition have been scrutinized and discussed. Watchdog agencies have researched the issues and made recommendations, publishing hundreds of reports identifying numerous problems and solutions. While improvements and reforms have been made, many major weapon systems continue to suffer from requirements creep, budget and schedule overruns, performance issues, and much more. According to an April 2009 report published by the United States Government Accountability Office on major weapon system acquisition, the Department of Defense's 2008 portfolio of major defense acquisition programs is already showing signs of trouble. Total research and development costs are on average 42 percent higher than the first estimate. Total acquisition costs are 25 percent higher than the first estimate. The average delay in delivering initial capabilities is 22 months (GAO, 2009).

The system for building and acquiring U.S. major weapon systems can be classified as a "CLIOS" system—Complex, Large-scale, Interconnected, Open, and Sociotechnical in nature (Sussman, 2007). This system of acquiring major weapons proves to be more complex and dynamic than ever imagined:

- There is rapidly changing technology.
- The time between concept design to delivery can take decades.
- There are social, political, and economic factors intertwined in the process.
- The end user is not the customer.
- The government has a need to retain specialized skills, yet has a limited number of programs on which to bid and "keep" defense contractors active while still meeting requirements.

- The U.S. defense industrial base is exclusively private-owned and thus governed by independent business decisions.
- The "military industrial complex" is both a burden and necessity to the U.S. government.

The U.S. major defense acquisition system is a very complex system with sub-systems and many internal and external influences. Much has been written and documented on this process. Repeatedly, groups have highlighted the immediate need of meeting planned schedules and budgets. Yet, there is little if any "improvement" on the issues that have plagued this industry and process for decades. The focal point of past research and publications concentrated on immediate solutions. Although solutions are necessary, the same issues and recommendations are given year after year.

In order to effectively address issues within this giant, complex system, it first must be treated as such. The U.S. major defense acquisition is increasing in size, scope, and complexity each year. The technology associated with major weapon systems is rapidly changing. Customer expectations are rising. Societal concerns such as workforce and economic development are playing an increasingly larger role. Politics continue to play a part in this system. The U.S. major defense acquisition system certainly qualifies as a CLIOS system—Complex, Large-scale, Interconnected, Open, and Sociotechnical in nature.

B. PURPOSE AND BENEFITS OF STUDY

The purpose of this study is to gain a better understanding of the system of acquiring major weapon systems as a whole, identify the emergent behavior of this system, find possible points of leverage for improvements to the system, and begin applying the CLIOS framework for a different approach and understanding of the system.

The goal is twofold: exploratory and descriptive. The study will explore previous research over the past decades concerning major weapon systems acquisition. Many of the findings outline the immediate needs of programs' ability to meet the set schedule and budget. The purpose of exploring the literature is to better understand how the system has behaved in the past, understand the areas of concern, and identify the pieces and players within the system. This study will offer an overview of significant research and literature published about major weapon systems acquisition.

This study will also describe the major defense acquisition system in order to ensure a holistic view is captured. Architecting the system will aid in the understanding of all of the systems at play within the major defense acquisition system as well as the interfaces.

C. RESEARCH QUESTIONS

This thesis will seek to answer the following research questions:

What are the issues identified in previous literature concerning U.S. major weapon systems acquisition?

How does the United States' system of acquiring major weapons compare to other top military spending nations?

What are the pieces, and/or who are the players, within the major defense acquisition system?

What other areas of the major defense acquisition system should be identified and researched when applying the CLIOS process?

Will the CLIOS process provide more understanding of the issues and enable solutions to the U.S major defense acquisition process that have not been previously reviewed or suggested?

D. METHODOLOGY

This exploratory and descriptive research is a case study of the major defense acquisition system. In order to effectively address issues within this giant, complex system, it first must be treated as such. The U.S. major defense acquisition process is only increasing in size, scope, and complexity with each year and certainly qualifies as a CLIOS system—Complex, Large-scale, Interconnected, Open, and Socio-technical in nature.

Chapter II will provide a comparison of the U.S. defense acquisition system to acquisition systems of other top military spending countries. It will end with a review of the major defense acquisition literature. This literature review will focus on the critical points of past and current knowledge of the issues surrounding the U.S. system of major weapon systems acquisition. This review will take a step back, explore, and analyze the research and publications, which identified issues and solutions towards U.S. major weapon systems acquisitions.

This exploratory approach will seek to identify gaps in the understanding of the system as a whole using the CLIOS Process as a framework. The CLIOS Process was created by Joseph Sussman, a professor in the Engineering Systems Division Program at the Massachusetts Institute of Technology (MIT), in order to "describe, understand, study, and, ultimately, to improve the performance of a…system…with wide-ranging economic, social, political, and environmental impacts" (Sussman, 2007, p. 6). This process will be introduced and reviewed in Chapter III of this study.

Chapter IV will present a partial CLIOS representation of the major defense acquisition system, which is an approach to architecting the system. This allows for describing the system, identifying subsystems, and describing components and links. Finally, Chapter V will conclude the study with key points and recommendations for improvements and further research on the system of acquiring major weapon systems.

II. REVIEW OF LITERATURE

A. INTRODUCTION

"It is clear that the problems being encountered today are similar to those of the past." (GAO, 1988)

Issues of increased costs, schedule delays, and degradation of performance requirements have plagued the United States' major weapons acquisition system for more than half a century. Scholars, researchers, and practitioners alike have studied the acquisition of major weapon systems. The pure quantity of reports generated makes it infeasible to review all of them. While a plethora of literature associated with this subject exists, only key reports have been chosen to provide a broad understanding of the issues, reasons and recommendations, and change initiatives provided by these researchers.

B. ISSSUES SURROUNDING MAJOR WEAPON SYSTEMS ACQUISITION

Marshall and Meckling (1959) conducted research on 22 major weapon systems to better predict the success of development and production. They identified three factors impeding the success of new programs: cost, time, and performance. Marshall and Meckling discovered cost increases of 200–300%. The actual costs for missiles were, on average, 5.1 times greater than the original estimates. On average, the actual costs for bombers were 3.1 times greater than the original estimates. Concerning time, Marshall and Meckling found data for only ten of the 22 systems they researched, where time extensions of 33–50% were the norm for newer weapon systems acquisitions. Of those ten systems, the average "slippage" from original estimate to actual availability was two years. Although performance was more difficult to quantify (such as the use of dollars and years for the previous two factors), Marshall and Meckling found that most of the 22 systems "fell short of performance expectations" (p. 21).

GAO (1969, November) reported on the Army's purchase of Sheridan weapon systems, M60A1E1 tank turrets, and M60A1E2 tanks. The tanks did not meet performance expectations nor schedule deadlines, with time and performance being two of the factors identified in Marshall and Meckling's research. Basically, the tanks were rapidly produced before adequate ammunition was created and tested. However, the acquisition of tanks continued, ultimately forcing them to be stored unused.

In 1969, Congress asked GAO to periodically report on the status of various major weapon systems. Fifty-seven programs were selected for the status on the acquisition of major weapon systems in February 1970 (GAO, 1970). However, only 38 had sufficient data for comparison. Initial cost estimates were significantly misjudged with estimates of program completion 50% higher than original estimates. Along with cost, performance was an issue on many of the programs. A large number of weapon systems had considerable variance in performance from the original estimate to the subsequent estimates before production. GAO also reported schedule delays on most programs ranging from six months to three years.

In June 1971, Perry, Smith, Harman, and Henrichsen published the findings of a two-year study on 24 major systems developed during the 1960s. The focus of these Rand researchers was the three factors identified by Marshall and Meckling: cost, schedule, and performance. Data for the three factors on all 24 systems was not available. However, Perry et al. were able to gather significant data as well as research causes and possible solutions. The cost data revealed an average increase of 40%, while schedule delays averaged 15% (Perry et al., 1971).

The GAO released a comprehensive review of selected Air Force, Navy, and Army major weapon systems for the 1971 status report (GAO, 1971, March). Estimated costs for 61 systems increased by $33.4 billion. In the 1972 status, GAO reviewed 47 other systems that had a net increase of only $2,287.6 million during 1971 (GAO, 1972). Between June 30, 1972 and December 31, 1972, a selection of 45 major weapon systems increased in cost by $585.7 million (GAO, 1973). For six months during 1973, there was a net increase of $7,016.1 million on the 55 major weapon systems under review (GAO, 1974). The 50 major weapon systems selected in 1974 saw a net increase of $13,242.5 million (GAO, 1975). Of those 50 major weapon systems, 22 were either 12 months or more behind schedule. Surprisingly, the GAO status report published in 1976 showed a net decrease of $2,355.9 million for the 47 major weapon systems analyzed January 1, 1975 to June 30, 1975 (GAO, 1976). GAO continued to release reports concerning increased costs on selected major weapon systems throughout the 1970s. See Table 1.

Table 1. GAO Status on Selected Major Weapon Systems

GAO Status on Selected Major Weapon Systems			
Year of Data	Net Increase / Decrease from Original Estimate	Year Published	# of Weapn systems
1970	$33.4 billion	1971	61
1971	$2.3 billion	1972	47
1972	$0.59 billion	1973	45
1973	$7.0 billion	1974	55
1974	$13.2 billion	1975	50
1975	($2.4 billion)	1976	47
1976	$14.4 billion	1977	52
1977	(no data)		
1978	$29 billion	1979	60
1979	$97.0 billion	1979	58

In his statement to congress in 1979, Jerome H. Stolarow, the Director of Procurement and Systems Acquisition, spoke to the lingering problem of cost growth saying, "Despite the level of anxiety, the publicity, and the many learned studies, the problem persists" (GAO, 1979, June, p. 2).

Certainly cost growth received much attention in the 1970s. However, after thoroughly reviewing 21 major weapon systems, GAO released a report in 1980, which identified and grouped issues into 17 categories: (1) operational or performance limitations, (2) survivability or vulnerability, (3) availability, (4) operational requirements, (5) reliability, (6) force mix requirements, (7) force capabilities, (8) operational utility, (9) affordability, (10) data reporting incomplete, (11) program concurrency, (12) adequacy of testing, (13) cost effectiveness, (14) program management, (15) development strategy, (16) system urgency, and (17) technical risk or problems. These 17 categories fell into a broader category of either mission effectiveness or program acquisition. Of the 75 issues found, 59% fell into the mission effectiveness category and 41% in the program acquisition (GAO, 1980).

A similar report was again issued in 1982. GAO selected 24 major weapon systems to analyze and found 71 issues that were grouped into 15 categories falling into one of two broad areas identified (GAO, 1982). The issues were identified as either a system effectiveness issue or a program acquisition issue. System effectiveness accounted for 37% of the issues, and program acquisition accounted for 63% of the issues.

In a statement before the Senate in 1984, Charles Bowsher, comptroller general of the United States, validated the trends in both cost growth and extended schedules over the past decade among major weapon systems and expressed concern at this continued problem, seemingly impossible to control. Bowsher emphasized the current seriousness of cost growth on major weapon systems despite the recognition it had received for decades (GAO, 1984). Four years later, GAO (1988) released another report underscoring the continued and recurring problems with cost growth, schedule delays, and deficiencies in performance for major weapon system acquisitions over the past 18 years.

Despite the reviews and publicity in the previous decades, major weapon systems acquisitions continued to have problems throughout the 1990s. In a report released December 1992, GAO listed the major persistent issues recurring from program to program, year to year: (1) Systems being acquired that may not be the most cost-effective solution to the mission need; (2) Overly optimistic cost and schedule estimates leading to program instability and cost increases; (3) Programs that cannot be executed as planned with available funds; (4) Program acquisition strategies that are unreasonable or risky at best; (5) Too much being spent before a program is shown to be suitable for production and fielding; and (6) Individuals seeking to improperly influence the outcome of the contracting process (GAO, 1992, p. 8).

A 1998 report released by GAO highlighted DoD's practice of allowing technology development to continue into product development rather than having known technology when production begins (GAO, 1998). Programs continued with much less knowledge and, thus, much higher risks. This uncertainty created production problems, increased costs, and schedule delays. Programs typically continued without the needed technology developed. In fact, many programs overpromised the technical performance without true knowledge of the undeveloped systems. These unknowns were not classified as high risks, and therefore, did not receive the needed attention in earlier stages of development (GAO, 1998).

By 2005, GAO (now the United States Government Accountability Office) had a portfolio of major weapon systems valued at $1.3 trillion (GAO, 2005). In her testimony before the Senate, Katherine Schinasi, Managing Director, Acquisition and Sourcing Management, repeated the issues of cost growth, schedule delays, quantity reduction, and reduced performance (GAO, 2005). Schinasi reported the acquisition process was not responsive to current needs and the United States was on an "unsustainable fiscal path" that "will gradually erode…our economy, our standard of living, and ultimately our national security" (GAO, 2005, p. 3). GAO's major weapon systems reviews revealed that programs with demonstrated or mature advanced technology had costs increases of less than one percent per unit cost. Whereas, those programs that began development with unproven technology had increased costs of approximately 21% over the first full estimate (GAO, 2005).

At the end of 2005, the Assessment Panel of the Defense Acquisition Performance Assessment Project released a report identifying over 42 issue areas within major weapon systems acquisition (DAPAP, 2005). Fifteen issue areas were stressed as key, going beyond cost, schedule, and performance: program structure, acquisition strategy, complex acquisition system, requirements process, joint requirements development, need for leadership, process discipline, oversight, requirements allocation, program management (PM) expertise, acquisition career path, industry motivation and behavior, and the Planning, Programming, Budgeting, and Execution (PPBE) process.

Again, in 2006, GAO issued a report detailing how continued recommendations and changes in policy have not rendered different results within major weapon systems acquisition (GAO, 2006).

C. REASONS AND RECOMMENDATIONS

Marshall and Meckling's (1959) conclusions were (1) early estimates were inaccurate, partly due to overoptimism and (2) estimates became more accurate as the system progressed. From their research, Marshall and Meckling discovered the penalties for underestimating cost and times were minimal compared to the opportunity for contractors to obtain the contract. Also, there was much uncertainty surrounding technological advances, hence the estimates becoming more accurate as the systems progressed. Marshall and Meckling (1959) noted the inaccuracies in cost, availability, and performance greatly affected military and procurement decisions.

In 1969, Elmer Staats, Comptroller General of the United States, gave a statement before the Subcommittee on Economy in Government, Joint Economic Committee on the Military Budget and National Economic Priorities (GAO, 1969, June). In his statement, Mr. Staats confirmed there was no standard procedure for contractors to adequately identify problems on major weapons programs concerning cost, schedule, and technical performance. Mr. Staats continued to confirm one of the greatest problems with major weapon systems acquisition was understanding how changes made to contracts impacted cost, schedule, and system performance.

The United States General Accounting Office (GAO) released a report to congress in November of 1969 stating improved management of the Sheridan weapon systems, M60A1E1 tank turrets, and M60A1E2 tanks would have minimized the situation (GAO, 1969, November).

The status on the acquisition of major weapon systems released by GAO in February, 1970 stated causes for the cost growth included (1) beginning acquisition before the weapon system had been demonstrated with probable successful development, (2) inadequate initial requirements and performance specifications, and (3) the difficulty to anticipate cost growth on major weapon systems that are produced over a long period of time (GAO, 1970).

Cost growth for the 61 systems in the comprehensive report in 1971 was attributed to various reasons: difference between planning and development estimates, changes in quantities, engineering changes, revisions to estimates, and inflation (GAO, 1971, March). Even more specifically, there were certain fundamental problems: (a) identifying the need for a weapon system and prioritizing, (b) determining performance characteristics and their feasibility, (c) quality suffering in support of cost-effectiveness, (d) organizational structure, and (e) cost estimation.

The GAO (1971, March) recommended four distinct changes for improvement: (1) have a standardized procedure for all military branches to request new systems based on mission need and to prioritize those systems, (2) institute standards for preparing, updating, and utilizing cost-effectiveness studies, (3) give more decision-making authority and control of operations to the corresponding military branch, and (4) standardize acquisition reports to contain summary of acceptability of the weapon, relation to and recognition of other complementary weapons, and current status.

In Perry et al.'s (1971) findings, the data indicated that meeting performance requirements was the main objective for programs. Schedule had a lesser priority than performance, and cost growth was allowable to facilitate meeting performance and schedule goals (Perry et al., 1971). Perry et al. (1971) isolated the causes for cost growth in three broad categories: technical uncertainty, scope change, and cost estimating error. It was obvious those programs with longer durations and higher technological advances were the chief offenders of cost growth. However, across the board, technical uncertainty affected all three factors of cost, schedule, and performance. Nonetheless, cost growth on fifty percent of the programs was attributed to scope change.

By 1972, it was evident a leading source of cost growth on major weapons systems was technical uncertainty. In response to this, GAO conducted a thorough examination of the policies and practices of testing and released a report on the importance of testing and evaluation in major weapon system programs (GAO, 1972). GAO examined 13 major weapons systems and concluded that testing objectives were adequate but were offset by inadequate testing plans. Testing and evaluation were not completed in time, and although the generated reports were adequate, the value of these reports was inadequate due to the lack of planning and actual testing. GAO recommended testing be conducted before major decisions or milestones, gaining control of waivers from required testing, and creating concise summary reports for all levels of management (GAO, 1972).

In many of the periodic updates to congress on selected major weapon systems, GAO repeatedly inserted the following statement:

> Overly ambitious performance requirements, combined with low initial cost predictions and optimistic risk estimates, lead almost inevitably to schedule slippages, performance degradations, and cost increases. Attempt to keep total program costs from rising lead to reductions in planned quantities that, in turn, increase unit cost. (GAO, 1975, p.24)

The primary reason for a net decrease in the weapon systems chosen in 1975 was due to economic factors, primarily inflation (GAO, 1976). However, cost growth continued and in his statement to congress, Stolarowe proclaimed, “Cost growth of weapon systems is a highly complex and multi-faceted problem involving economics, military judgment and politics” (GAO, 1979, June, p. 4). Stolarowe stated the factors leading to increased costs were interrelated and impossible to separate. One factor was preliminary cost estimates. Stolarowe acknowledged over-optimistic cost estimates become more accurate and realistic the further along in the development cycle because more is known about the system. Technology was the second factor because high technology systems were more complex needing more research, development, design, testing, maintenance, support, etc. The third factor was inflation, and the fourth, funding, both causing production delays, changes in production rates, and production inefficiencies (GAO, 1979, June).

GAO’s reports to congress in 1982 and 1983 had many broad and specific recommendations concerning major weapon system acquisitions (GAO, 1982; GAO, 1983). First, risk must be minimized and system effectiveness ensured through improved testing and limitations on procurement funds until those risks and uncertainties are resolved. Second, congress could make better decisions if it had more information on cost, schedule, and performance of major weapon systems provided by the Department of Defense. Third, requirements should be established in accordance with mission needs and maintained through completion of the program. Fourth, more analyses of alternatives must be conducted to ensure the weapon system is the best all around. Fifth, every opportunity must be taken to ensure costs are reduced. Finally, a more effective management structure must be established to efficiently accomplish program objectives (GAO, 1982; GAO, 1983).

From research conducted by the General Accounting Office, Charles A. Bowsher (GAO, 1984) reasoned cost growth could be more controlled if cost estimating procedures and reporting of actual costs were improved. Bowsher recognized the vagueness and conflicting guidelines for cost estimating. He conveyed numerous reasons for cost growth to the Senate: DoD's implementation of the guidance was weak, cost estimates lack definite structure, definition of programs lacks consistency, documentation was insufficient, risks were not properly accounted for, inflation was not consistently recognized ,or it was used to hide other costs, improvements were needed in the direction provided by DoD, DoD estimates were based on inaccurate or optimistic data, program cost estimates were forced to conform to the budget, relevant program costs were excluded, and cost estimates would be more reliable by using independent cost estimator recommendations (GAO, 1984).

The 1988 GAO report summarized 18 years of systemic causes of cost growth, schedule delays, and performance shortfalls. Several factors were highlighted: (1) no funding for analyzing alternatives, which forces one design; (2) premature commitment to an unproven design; (3) decisions made during program planning limit program managers; (4) lack of upper-management commitment to weapons requirements for design; (5) insufficient funding; (6) inappropriate external management direction; (7) more commitment to the development schedule existed than commitment to correcting serious problems; (8) process used by DoD to determine weapon system requirements; and (9) general instability with the acquisition process (GAO, 1988).

In 1992, GAO attributed many of the persistent, systemic problems to "a prevailing culture that is dependent on generating and supporting new weapons acquisitions" (GAO, 1992, p. 9). This culture created an environment encouraging the selling of programs, and GAO suggested changes be made to the system of incentives and opportunities surrounding the acquisition process (GAO, 1992). This was reiterated in GAO's 1997 report where GAO reviewed six weapons in low-rate production (LRIP) and 22 weapons in full-rate production (GAO, 1997). DoD tended to buy large quantities of untested weapons in LRIP, which caused many decreases in production rates of tested and proven weapons in full production. These proven weapons not only experienced reduced production rates but also extended schedules, which, in turn, resulted in higher costs per unit. The larger investment in untested weapons resulted in increased costs and performance risks. They suggested DoD buy limited quantities of weapons during LRIP until appropriate operational tests and evaluations were conducted (GAO, 1997).

GAO (1998) compared commercial practices to DoD practices concerning technology development. Unlike leading commercial firms, DoD consistently began or continued programs without the needed technology fully developed, as mentioned in the numerous, previous reports. GAO observed DoD acquisition had a culture or environment that encouraged such practices, which led to high costs and schedule increases. Recommendations included (1) having standards applied to individual programs concerning timing and quality of production-related knowledge, (2) splitting forced a line of text to next page for more text at top of page technology development from weapon systems programs for higher knowledge standards, and (3) allowing program managers to identify unknowns as high risks early without criticism or loss of funding (GAO, 1998).

In her statement to the Subcommittee on AirLand, Committee on Armed Services, U.S. Senate, Schinasi called for immediate change to the acquisition system, pleading with decision makers to make the necessary difficult choices and decisions based in reality and to stop being complacent to cost growth, schedule slippages, and performance shortfalls (GAO, 2005). Schinasi acknowledged DoD's policy had adopted a knowledge-based, evolutionary approach. However, DoD's practice was the opposite. Schinasi recommended truly implementing the knowledge-based, evolutionary approach to acquisition to enable "developers to rely more on available resources rather than making promises about unproven technologies" (GAO, 2005, p. 6). This policy fostered a more manageable environment, since technology would not be brought into product development unless it was first demonstrated to meet requirements. Nonetheless, programs continued to start development with immature technologies.

To emphasize the need for decision makers to begin making the necessary but difficult decisions, Schinasi (GAO, 2005) outlined the current, undisciplined progression to product development:

- DoD's requirements create more demand for programs than resources.
- DoD approves too many highly complex and interdependent programs.
- After a program is approved, DoD adds more requirements, increasing costs and risks.
- Once programs start, the budgeting process exacerbates the problems.
- Programs are funded annually and department wide.
- Priorities have not been established.
- Competition for funding increases.
- Success is viewed by obtaining next incremental funding, not by delivering capabilities.
- Bad news about programs is suppressed and testing can be skipped to lower costs, so as not to lose funding.
- Senior officials make across-the-board cuts rather than make hard decisions about individual programs.
- Therefore, the acquisition system fosters a culture of beginning programs with too many unknowns, risks, and, eventually, shortfalls and higher costs (GAO, 2005).

Schinasi (GAO, 2005) gave specific recommendations for improvement: (a) constrain requirements; (b) proved definitive business cases for investments; (c) enable science and technology organizations to take the responsibility for technology; (d) develop a workforce to manage requirements, source selection, and knowledge-based acquisitions; and, finally, (e) enforce knowledge capture and use by decision makers before investing or moving forward with programs. These recommendations demanded a disciplined process for requirements and funding (GAO, 2005).

The 2006 report issued by GAO found DoD still skipping important steps in the knowledge-based process and continuing to chase "revolutionary leaps in capability" before gathering pertinent knowledge and before technology had matured enough. In fact, 80% of the programs reviewed for this report had not followed the knowledge-based process before committing to system development (GAO, 2006).

D. INITIATIVES TO IMPROVE ACQUISITION OF MAJOR WEAPON SYSTEMS

> The perennial procurement and contracting cycle—going back many decades—of adding layer upon layer of cost and complexity onto fewer and fewer platforms that take longer and longer to build must come to an end. There is broad agreement on the need for acquisition and contracting reform in the Department of Defense. There have been enough studies. Enough hand-wringing. Enough rhetoric. Now is the time for action.
>
> United States Secretary of Defense, Robert Gates, April 6, 2009

The hundreds of reports released by GAO, the RAND Corporation, and other researchers did not go unnoticed. Over the past 50 years, the United States has implemented numerous initiatives for improvement of the acquisition system. Over the past decades, the fundamental nature of major weapon systems acquisition has changed significantly. Unfortunately, as proven in the literature above, even with perpetual reports and committees or initiatives, programs continued the cycle of underperforming, extending the schedule, and increasing the costs.

Needed improvements were recognized as early as 1949 with the formation of the first Hoover Commission. The first Hoover Commission, also known as the Commission on the Organization of the Executive Branch of Government, did not exactly examine the acquisition system as a whole in 1949. However, it did review the role of the Secretary of Defense within the process and the structure of the military (McKinney et al., 1994). While the second Hoover Commission in 1955 was more concerned with commodity goods than weapon systems, it did review the acquisition system more thoroughly looking to achieve greater efficiency within the procurement system (McKinney et al., 1994).

During the 1960s, the U.S. Secretary of Defense, Robert McNamara, approached the U. S. acquisition system much as he did as president of the Ford Motor Company, a large American business (McKinney et al., 1994). McNamara had a bachelor's degree in economics and philosophy from the University of California, Berkeley, and a master's degree from Harvard Graduate School of Business. McNamara aggressively questioned, sought alternatives, and stimulated progress. He was an advocate of "one defense policy," not three conflicting policies for each of the military branches (DefenseLink, 2009). Some of McNamara's innovations, such as the Total Package Procurement, had unintended consequences like budget overruns. However, some programs such as the introduction of a campaign to reduce unnecessary duplication within defense procurement had positive impacts (McKinney et al., 1994).

In 1970, the first independent, government sponsored commission to thoroughly examine the weapon systems acquisition process was the Fitzhugh Commission, also known as the Blue Ribbon Defense Panel. The Fitzhugh Commission was also the first to address the political aspects of the acquisition system by acknowledging Congress' tendency to micromanage the Department of Defense. The Fitzhugh Commission recommended management improvements and changes in contracting regulations (McKinney et al., 1994). A year later in 1971, the introduction of DoDD 5000.1 was a major breakthrough in the acquisition process. It illustrated three critical transition points, which were later referred to as milestones: (1) Program Initiation, (2) Begin Full-Scale Development, and (3) Begin Production/Deployment (Acquisition History Project, 2009).

Two years after the report issued by the Fitzhugh Commission, 1972, the Government Procurement Commission also recommended management improvements and changes in contracting regulations. However, what set the Government Procurement Commission apart from the Fitzhugh Commission was the recommendation that

Congress have a better understanding of defense as a whole and a more strategic role in defense acquisition (McKinney et al., 1994).

The Carlucci Initiatives of 1981 had an aggressive agenda: reduce length of acquisition process, increase cost savings, improve readiness, and strengthen the defense industrial base (Acquisition History Project, retrieved 2009). After reviewing the entire system, 32 initiatives were implemented. See Table 2 for a summary of the Carlucci Initiatives.

Table 2. Carlucci Initiatives

#	Initiative	#	Initiative
1	Reaffirm Acquisition Management Principles	**17**	Decrease DSARC briefing and data requirements
2	Increase use of Preplanned Product Improvement	**18**	Budget for inflation
3	Implement mutliyear procurement	**19**	Forecast business base conditions
4	Increase program stability	**20**	Improve source selection process
5	Encourage capital investment to enhance productivity	**21**	Develop and use standard operation and support systems
6	Budget to most likely costs	**22**	Provide more appropriate design-to-cost-goals
7	Use economicial production rates	**23**	Implement acquisition process decisions
8	Assure appropriate contract type	**24**	Reduce number of DSARC milestones
9	Improve system support and readiness	**25**	Submit MENS with Service POM
10	Reduce administrative costs and time	**26**	Revise DSARC membership
11	Budget for technological risk	**27**	Retain USDR&E as Defense Acquisition Executive
12	Provide front-end funding for test hardware	**28**	Raise dollar threshold for DSARC review
13	Reduce governmental legislation related to acquisition	**29**	Integrate DSARC and PPBS process
14	Reduce number of DoD Directives	**30**	Increase PM visibility of support resources
15	Enhance funding flexibility	**31**	Improve reliability and support
16	Provide contractor incentives to improve reliability	**32**	Increase use of competition

[From Holbrook, 2003, p. 10].

The Reagan administration created the Grace Commission, also known as the President's Private Sector Survey on Cost Control, to examine the entire government, including defense acquisition, looking for ways to avoid wasteful public spending. In their report of 1983, the Grace Commission criticized the "excessively complex set of regulations" surrounding the acquisition process and, much like the Fitzhugh Commission, criticized Congress for micromanaging weapons acquisitions that have a cost impact for the interference. Later the Packard Commission built on the Grace Commission's call for greater stability in defense programs and budget (McKinney et al., 1994).

Former President Ronald Reagan, as well, chartered the Packard Commission, a blue ribbon commission (Acquisition History Project, retrieved 2009). The Commission reviewed the management of the acquisition process, the budget process, and the legislative oversight. After studying the defense acquisition system, the Packard Commission recommended the appointment of a full-time Under Secretary of Defense for Acquisition, which was put into policy in 1986 (Acquisition History Project, retrieved 2009). Furthermore, the Packard Commission called for unity and trust among Congress, the Executive Branch, the military, and defense industries (McKinney et al., 1994).

Like many other initiatives and reports before it, the Goldwater-Nichols Act of 1986 mandated revolutionary reform for national defense. It was the Goldwater-Nichols Act that actually implemented most of the recommendations by the Packard Commission (Jones, 1999).

At the time of this writing, the latest reform effort was passed into law on May 22, 2009. The Weapon Systems Acquisition Reform Act of 2009 was a bill proposed to improve the organization and procedures of DoD concerning the major weapon systems acquisition. This new law created a position within DoD—Director of Cost Assessment and Program Evaluation. This new position will provide advice relating to acquisition program cost estimation and analysis to the Secretary of Defense and DoD officials (Library of Congress, 2009).

“Poor execution of the revised acquisition policy is a major cause of DoD’s continued problems” (GAO, 2006). See Table 3 for a partial listing of programs executed for the purpose of improving acquisition system.

Table 3. Acquisition Improvement Initiatives

Year	Improvement Initiatives
1949	First Hoover Commission
1953	Rockefeller Committee
1955	Second Hoover Commission
1961	McNamara Initiative
1970	Fitzhugh Commission / Blue Ribbon Defense Panel
1971	DoDD 5000.1 was issued
1972	Commission on Government Procurement
1978	Defense Science Board Acquisition Cycle Study
1979	Defense Resources Management Study
1981	Carlucci Initiatives
1983	Grace Commission / President's Private Sector Survey on Cost Controls
1986	Packard Commission / Presdident's Blue Ribbon Defense Commission
1986	Goldwater-Nichols Act
1989	Defense Management Review
1994	Process Action Team on Oversight and Review
2009	Weapon Systems Acquisition Reform Act

E. TOP MILITARY SPENDING COUNTRIES

The United States is the largest consumer of military goods in the world. According to the Stockholm International Peace Research Institute (SIPRI) (2008)—a Swedish-based independent research institute focusing on international security, arms control, and disarmament—the United States’ military acquisition expenditures comprise 41.5% of the world’s total military expenses. The top five military spending countries, which include the U.S.’s 41.5%, make up 60% of the world market share. See Table 4 for details on the top 15 military spending countries as of 2008.

Table 4. The Top 15 Military Spender Countries in 2008

Rank	Country	Spending ($ b.)	World Share (%)	Spending per Capita ($)	Share of GDP, 2007 (%)[a]	Change, 1999-2008 (%)
1	USA	607	*41.5*	1967	*4*	*66.5*
2	China	[84.9]	*[5.8]*	[63]	*[2.0]*	*194*
3	France	65.7	*4.5*	1061	*2.3*	*3.5*
4	UK	65.3	*4.5*	1070	*2.4*	*20.7*
5	Russia	[58.6]	*[4.0]*	[413]	*[3.5]*	*173*
Sub-total top 5		**882**	***60***			
6	Germany	46.8	*3.2*	568	*1.3*	*-11.0*
7	Japan	46.3	*3.2*	361	*0.9*	*-1.7*
8	Italy	40.6	*2.8*	689	*1.8*	*0.4*
9	Saudi Arabia[b]	38.2	*2.6*	1511	*9.3*	*81.5*
10	India	30.0	*2.1*	25	*2.5*	*44.1*
Sub-total top 10		**1 084**	***74***			
11	South Korea	24.2	*1.7*	501	*2.7*	*51.5*
12	Brazil	23.3	*1.6*	120	*1.5*	*29.9*
13	Canada	19.3	*1.3*	581	*1.2*	*3.4*
14	Spain	19.2	*1.3*	430	*1.2*	*37.7*
15	Australia	18.4	*1.3*	876	*1.9*	*38.6*
Sub-total top 15		**1 188**	***81***			
World		**1 464**	***100***	**217**	***2.4***	***44.7***

[ ] = estimated figure; GDP = gross domestic product.
[a] The figures for national military expenditure as a share of GDP are for 2007, the most recent year for which GDP daa is available.
[b] The figures for Saudi Arabia include expenditure for public order and safety and might be slight overestimates.

Due to public access and/or language barriers, it was not possible to gather information on all of the above countries' defense acquisition systems. However, basic information about defense acquisition was found on seven of the top 15 countries: United States, France, Germany, United Kingdom, Australia, Japan, and South Korea.

1. The United States' Defense Acquisition System

According to the CIA world Factbook, the United States (U.S.) has the largest economy in the world. The U. S. has a constitution-based federal republic government with a strong democratic tradition. It has a population of 307,212,123. The U.S. Armed

Forces has four branches: U.S. Army, U.S. Navy including the Marine Corps., U.S. Air Force, and U.S. Coast Guard (CIA World Factbook, 2009).

The U.S. political system has a series of checks and balances concerning DoD weapon systems acquisition. Congress plays a significant role in oversight and controls the "power of the purse" (Kausal, 1999, p.4–10). The DoD requests specific weapon systems and justifies the need. From this, the President submits a budget to congress. After deliberation and modifications, it may be passed, and then the budget is sent back to the President for his signature or veto. This process typically takes eight months. See Figure 1 for the typical flow of budget for the U.S (Kausal, 1999).

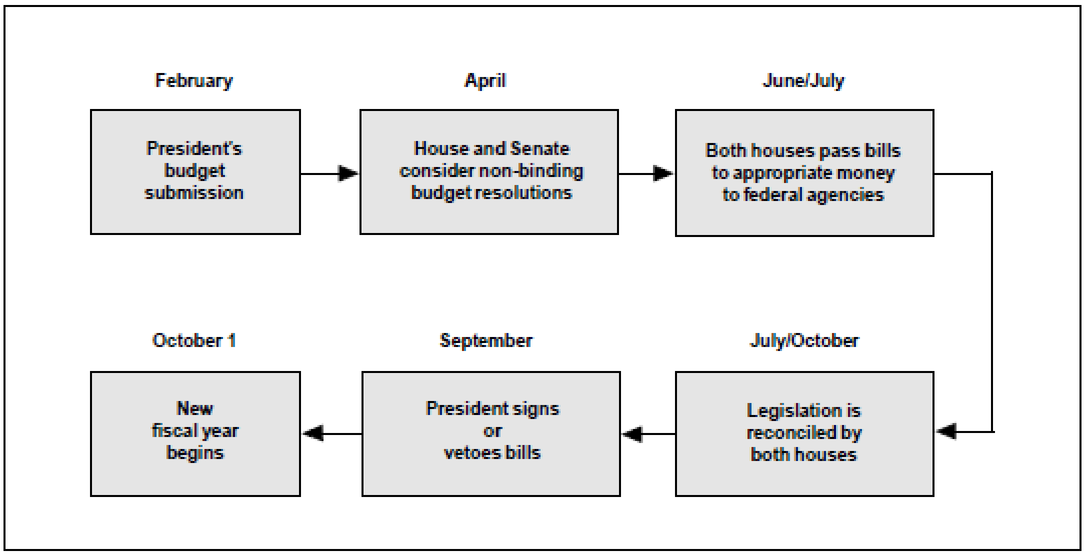


Figure 1. Typical Flow of Budget [From: Kausal, 1999].

The DoD has three decision-making support systems for defense acquisition: Joint Capabilities Integration and Development System (JCIDS); Planning, Programming, Budgeting, and Execution (PPBE) System; and Acquisition Management System (DoD 5000.02). Figure 2 depicts these three systems enclosed within the "Big 'A' Acquisition Process."

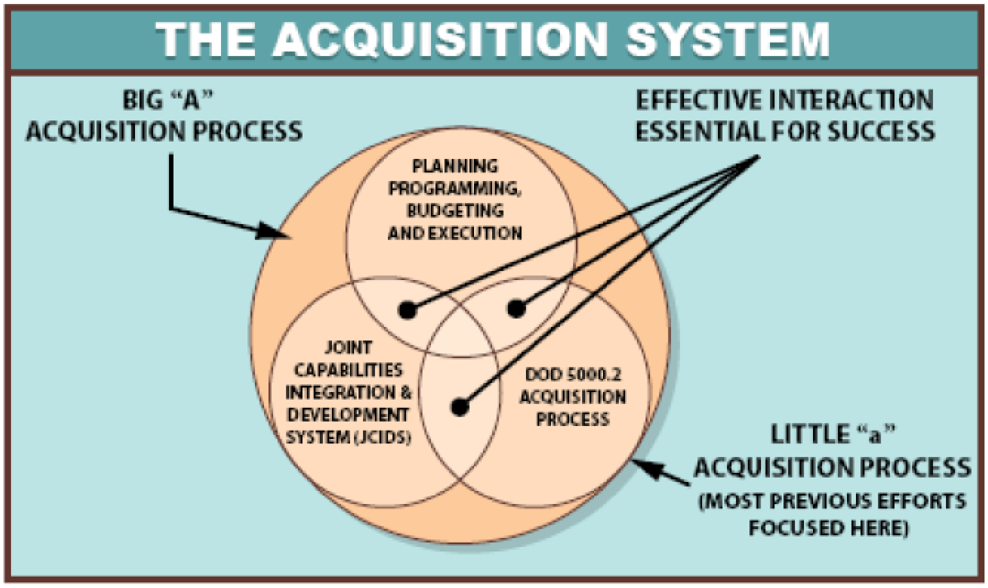


Figure 2. The Acquisition System [From: Defense Acquisition Performance Assessment Report, 2006, p. 4].

The Joint Capabilities Integration and Development System determines future military needs. Each of the military services is responsible for identifying gaps within its own mission requirements, determining new mission needs, and generating requirements to meet those needs (DAU, 2009). All major weapon systems acquisitions, also known as Acquisition Category (ACAT) I programs, are founded on validated mission needs where the requirement is approved by the Joint Chiefs of Staff. The acquisition system is managed by the Under Secretary of Defense (Acquisition and Technology) (Kausal, 1999).

The Planning, Programming, Budgeting, and Execution System helps with creating DoD's piece of the President's Budget (DAU, 2009). Three of the phases—planning, programming, and budgeting—usually take three years. Planning is a six-month process and begins two years before the fiscal year it will be requested. During Programming, the military branches issue their Program Objective Memoranda (POM), stating their requirements to the Joint Chiefs of Staff (JCS). The military branches, the JCS, and the Office of Secretary of Defense discuss over a period of time and agree to a number of programs. The Secretary of Defense then issues a Program Decision

Memorandum (PDM) (Kausal, 1999). Finally, in the Budgeting phase, the DoD budget is finalized and submitted to be included in the President's budget (Kausal, 1999).

The Acquisition Management System (DoD 5000.02) contains the policies and procedures guiding DoD and consists of five phases, three milestones, and three decision points. Once the Materiel Development Decision has been made, the Milestone Decision Authority will allow entrance into any point in the system as seen in Figure 3 as long as phase-specific entrance criteria and statutory requirements have been met (DoDI 5000.02, 2008).

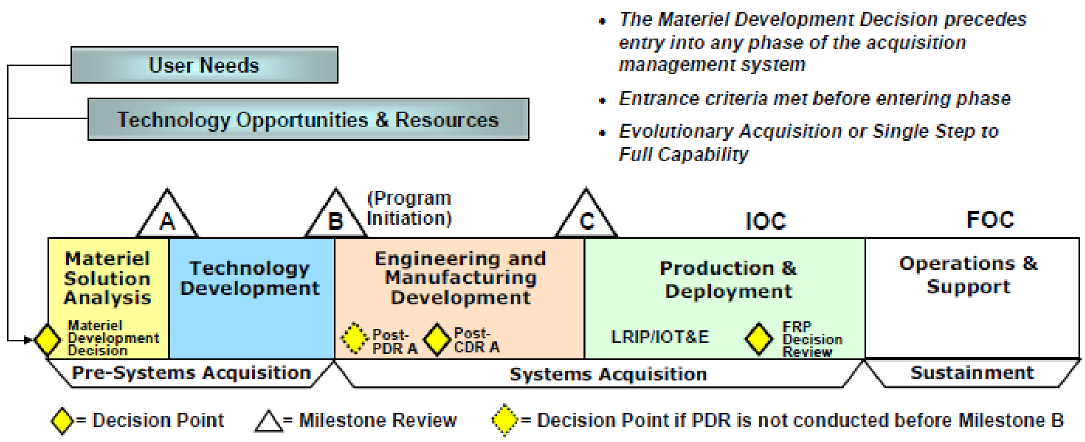


Figure 3. Defense Management Acquisition System [From: DoDI 5000.02, 2008].

The United States has more than 80 major weapon systems currently in development (DoD FY2009 Budget Request Summary Justification). The acquisition of major weapon systems represents 20 percent of the Department of Defense's annual spending on purchases (Hearing on the Reform of Major Weapon Systems Acquisition, Defense & Security News—ByU.S.Government on May 5, 2009).

2. France's Defense Acquisition System

According to the CIA World Factbook (2009), France has the eighth largest economy in the world. France's government is a republic, and the country has a population of 64,057,792. France has four military branches: Army, Navy, Air Force, and National Gendarmerie (CIA World Factbook, 2009).

Parliament creates the laws concerning the defense budget, military policy, and defense organizational structure (Kausal, 1999). The Ministry of Defense implements these policies with the aid of the Joint Armed Forces Chief of Staff, the Delegation General for Armaments (DGA), and the Secretariat General for Administration (Kausal, 1999). See Figure 4 for more detail.

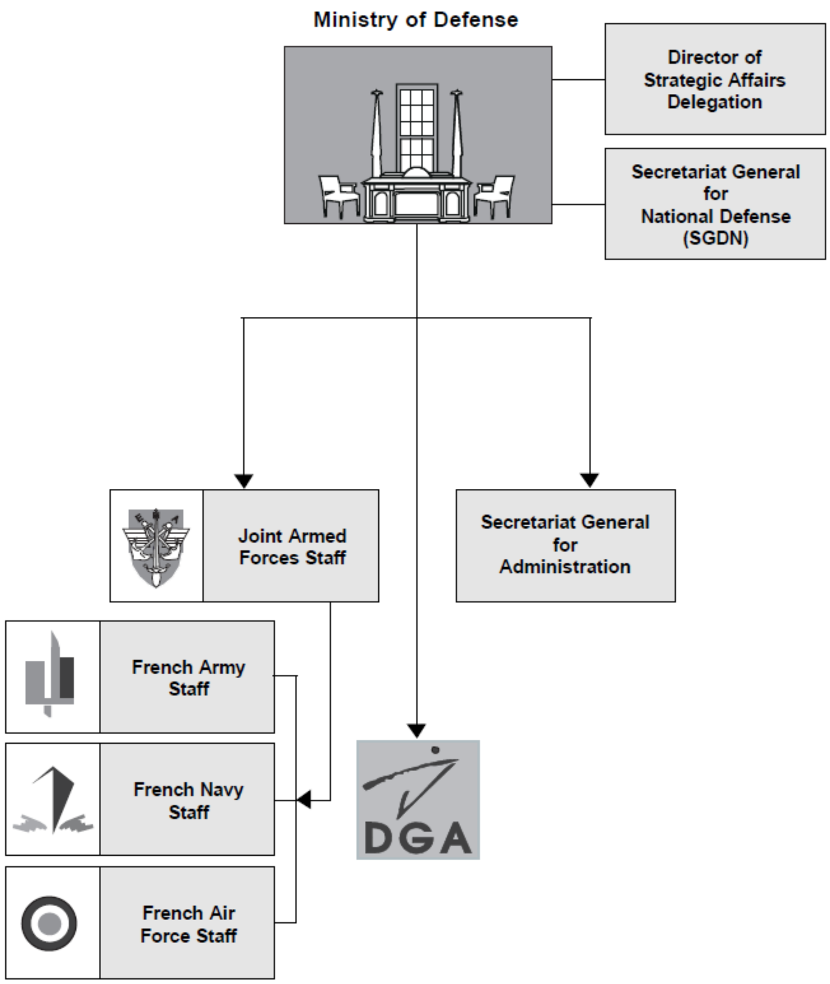


Figure 4. Organization of National Defense [From: Kausal, 1999].

The DGA was created in 1961 and is responsible for France's weapon systems acquisitions (Kausal, 1999). Like the U.S., France has had problems of schedule delays and cost overruns with its complex, major weapons acquisitions. Also like the U.S., France has undergone acquisition reform to address those issues and to allow for greater flexibility in the process. The new acquisition process consists of stages and phases. The four stages are preparation, design, realization, and utilization (Kausal, 1999) (see Figure 5).

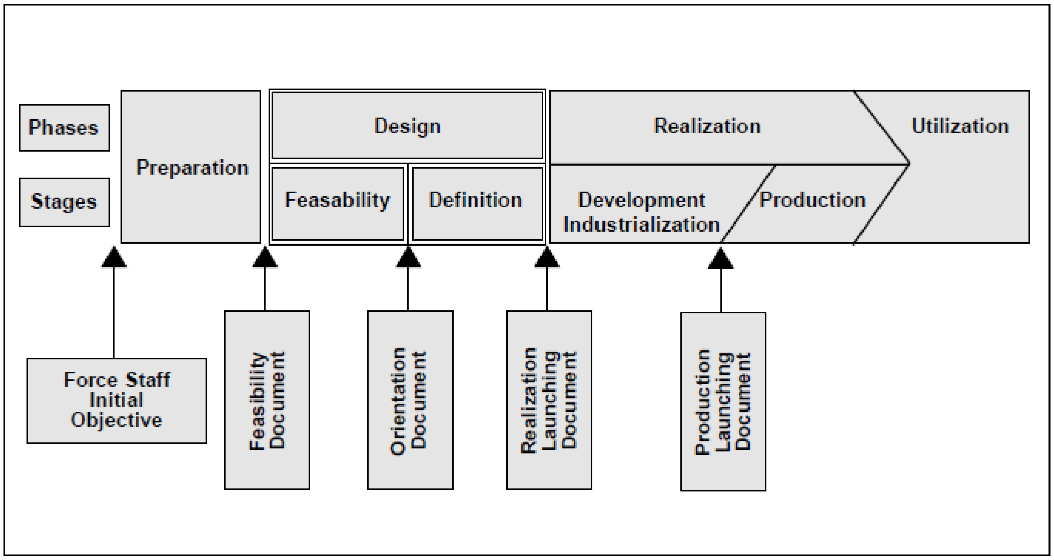


Figure 5. New Acquisition Process.

During the Preparation Stage, operational requirements are outlined while current assets are evaluated. Recommendations are given to fill the identified gaps such as developing advanced technology or buying off-the-shelf solutions. Throughout this preliminary stage, many technical and financial studies are made, and research and development programs are initiated. By the end, operational requirements have been refined and outlined, resources have been decided, and preliminary budgets have been set (Kausal, 1999).

At the Design Stage, a decision is made, so the Feasibility and Definition Phases can begin. A program director and a program officer are appointed when a joint decision has been made to move forward. At this point, 80% of the costs of the program will be determined, leaving 20% for disposal during the development stage. The defense industry submits proposals. Once operational and technical specifications are defined, the defense industry will compete for the contract (in most cases), and an industry partner is chosen (Kausal, 1999).

The Realization (Development/Industrialization and Production) Stage involves a formal schedule, performance requirements, and a set budget. A very rigorous procedure is put into place for the development and development tests, ensuring no duplication between the contractor and DGA. The government firmly commits to a multi-year contract with the contractors. This gives the contractors stability needed to invest in production at lower cost (Kausal, 1999).

Finally, the Utilization Stage begins after a weapon system has been formally put into operational use. This, of course, is preceded by much testing and acceptance by the DGA. During the course of the system's lifetime, it is assessed for needed updates, ultimately resulting in engineering changes (Kausal, 1999).

3. Germany's Defense Acquisition System

According to the CIA World Factbook, Germany has the fifth largest economy in the world (in purchasing power parity), only behind the U.S., China, Japan, and India. Germany is a federal republic with a population of 82,329,758. Germany's military, the Federal Armed Forces, has five separate branches: Army, Navy, Air Force, Joint Support Services, and Central Medical Service (CIA World Factbook, 2009).

Germany has a Federal President, who is Head of State, as well as a Chancellor, who is Head of the German Federal Government (Kausal, 1999). The Chancellor plays two roles in defense: (1) sets policy for military issues and (2) in times of war, becomes the power of command. Each of the individual military branches develops requirements and submits them to the Director General of Armaments (DGA) for review and approval. The DGA is also responsible for providing targets for cost, schedule, and performance. The Federal Office of Military Technology, which falls under the Federal Ministry of Defense (FMOD), is a civilian-run operation and is in charge of weapon systems acquisitions, among other responsibilities. However, all budgets for major weapon systems acquisition must be approved by Parliament (Kausal, 1999).

Major weapon systems are developed in phases: Pre-Phase, Definition Phase, Development Phase, Procurement Phase, and In-Service Phase. See Figure 6 for more detail.

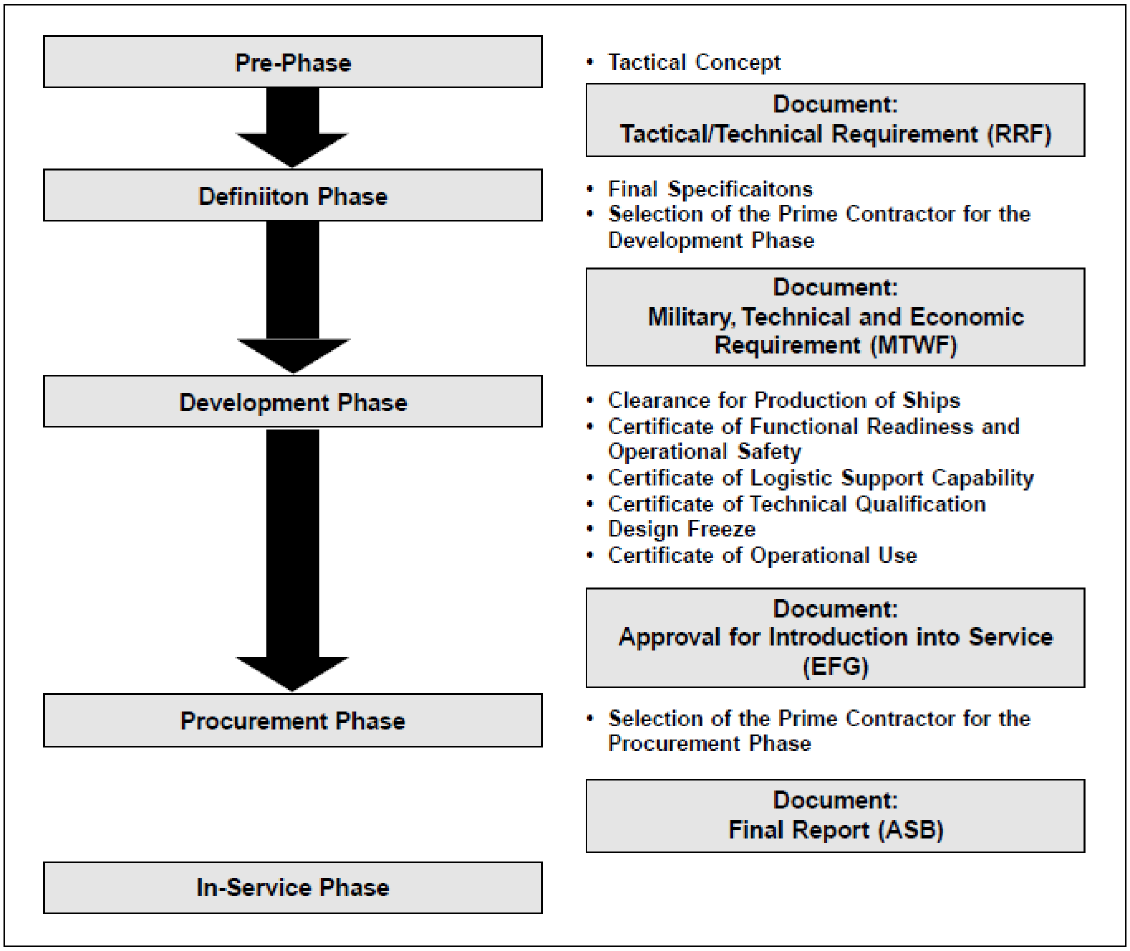


Figure 6. Weapon Systems Development Process [From: Kausal, 1999, p. 2–21].

At the end of each phase and before entering a new phase, a decision and approval are required before the program can continue (Kausal, 1999). The Pre-Phase verifies the military mission needs. During this phase, military and industry work together to evaluate needs, solutions, and alternatives. Once a solution has been finalized, submitted for review, and approved, Definition Phase begins. Definition Phase finalizes weapon specifications and establishes the project manager and team working groups. It is only finished when the Development Baseline is approved. After this approval, the Development Phase begins. At some point in this phase, the prime contractor is chosen through a fair and open competition, with the development contract defining the responsibilities of the contractor. Operational testing is conducted during this phase, and it concludes with the approval of the document, Approval for Production. The Procurement Phase includes series production and the selection of a contractor for the entire procurement phase, again this is accomplished through fair and open competition. At the end of the Procurement Phase, the weapon system is handed over to the military, which begins the In-Service Phase (Kausal, 1999).

4. The United Kingdom's Defense Acquisition System

The United Kingdom (U.K.) has the sixth largest economy, according to the CIA World Factbook (2009). The U.K.'s government is a constitutional monarchy and Commonwealth realm. The population is 61,113,205. The U.K.'s military branches are the Army, Royal Navy, and Royal Air Force (CIA World Factbook, 2009).

The U.K. has both a Monarch and a Prime Minister. The Monarch is the Head of State and the Commander in Chief of the Armed Forces. However, she is constitutionally bound to take advice from the Prime Minister. It is the House of Commons that formally approves funds for weapon systems acquisition. However, the House of Commons approves the budget only, it does not have a say on individual programs. Individual major weapon systems needs and requirements are determined by the Equipment Approvals Committee, who compares costs to operational effectiveness, as well as other trade-off analyses. The committee then gives recommendations to the Ministry of Defence. Also, the Defence Evaluation and Research Agency conducts research into advanced technology and makes recommendations to the Ministry of Defence (Kausal, 1999).

The actual acquisition and management of major weapon systems are the responsibilities of the Defence Procurement Agency, which is accountable to Parliament. It is the Agency's goal to obtain the best value for money and this is accomplished through competitive bids. Foreign contractors are free to bid on the majority of defense acquisitions, as the prime contractor or as subcontractors. Like the U.S., the U.K. has had issues in cost, schedule, and performance on major weapon systems acquisition. Therefore, after much review, the Labour Government created the Smart Procurement Initiative in 1998, which takes a systems approach to acquisitions, improves requirements management, strengthens partnerships with industry, controls schedule, commits to longer periods for acquisition funding, and implements incremental acquisition (Kausal, 1999).

The U.K.'s new acquisition system reduces the number of formal approvals and phases. The acquisition system begins with the Concept Phase to identify best alternatives for mission needs. Approval for the necessary resources is given at the Initial Gate before beginning the Assessment Phase. During the Assessment Phase, a single option is chosen from alternatives for demonstration. Also during this phase, technical risks are reduced to an acceptable level, requirements are set and linked to mission needs, firm life-cycle costs are set, and up to 15% of total project costs can be spent (Kausal, 1999).

The Main Gate is the major approval point where commitment to an individual project is made. It is at this point that projects are cancelled, if they do not provide an acceptable trade-off between cost and performance—best value for money. If approval is given, then the program proceeds to the Demonstration Phase where a contractor is selected and a contract is signed for development and production. Right through the Demonstration Phase, design continues as requirements and performance are met at a fixed cost. Models or prototypes are built to demonstrate integration and capabilities. The Manufacture Phase starts production of the system. The system will be tested by the manufacturer and end-user before it is officially accepted and put into service. See Figure 7 for more detail.

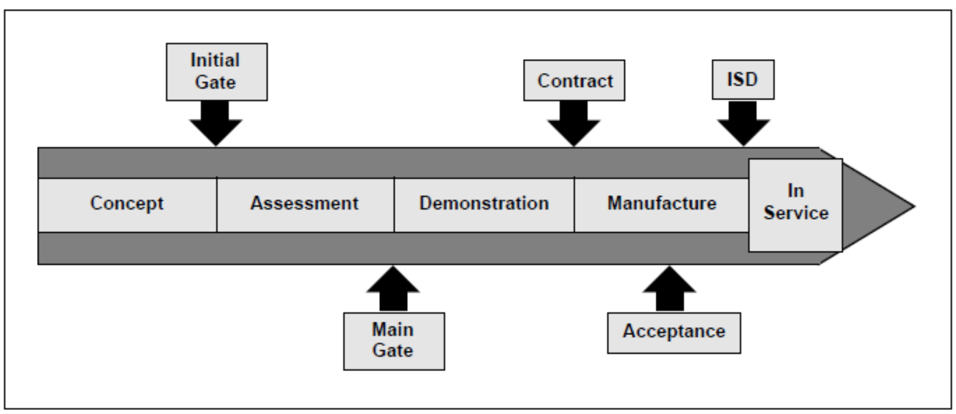


Figure 7. The U.K.'s Defence Procurement Phases [From: Kausal, 1999, p. 3–24].

5. Australia's Defense Acquisition System

The island, country, and continent—Australia—has the 18th largest economy compared to other countries (CIA World Factbook, 2009). Australia's government is a federal parliamentary democracy and a Commonwealth realm. It has a population of 21,262,641. The Australian Defense Force has four braches: Australian Army, Royal Australian Navy, Royal Australian Air Force, and Special Operations Command (CIA World Factbook, 2009).

Australia has the world's largest coastline to defend, yet it has no identifiable threat. Therefore, Australia struggles with how to structure defense as well as how much to invest. Australia's Defence Organization is the combination of the Australian Defence Force (ADF) and the Department of Defence. The Chief of Defence Force (CDF) is in command of the ADF, and the Secretary of Defence is head of the Department of Defence. Both of these positions are accountable to the Minister of Defence and the government for the management of Defence. Like many countries, Australia's defense acquisition system has undergone major reform. To gain better understanding and control of acquisition, a new structure was created for the Defence Acquisition Organisation (DAO) (Kausal, 2000). See Figure 8 for more detail.

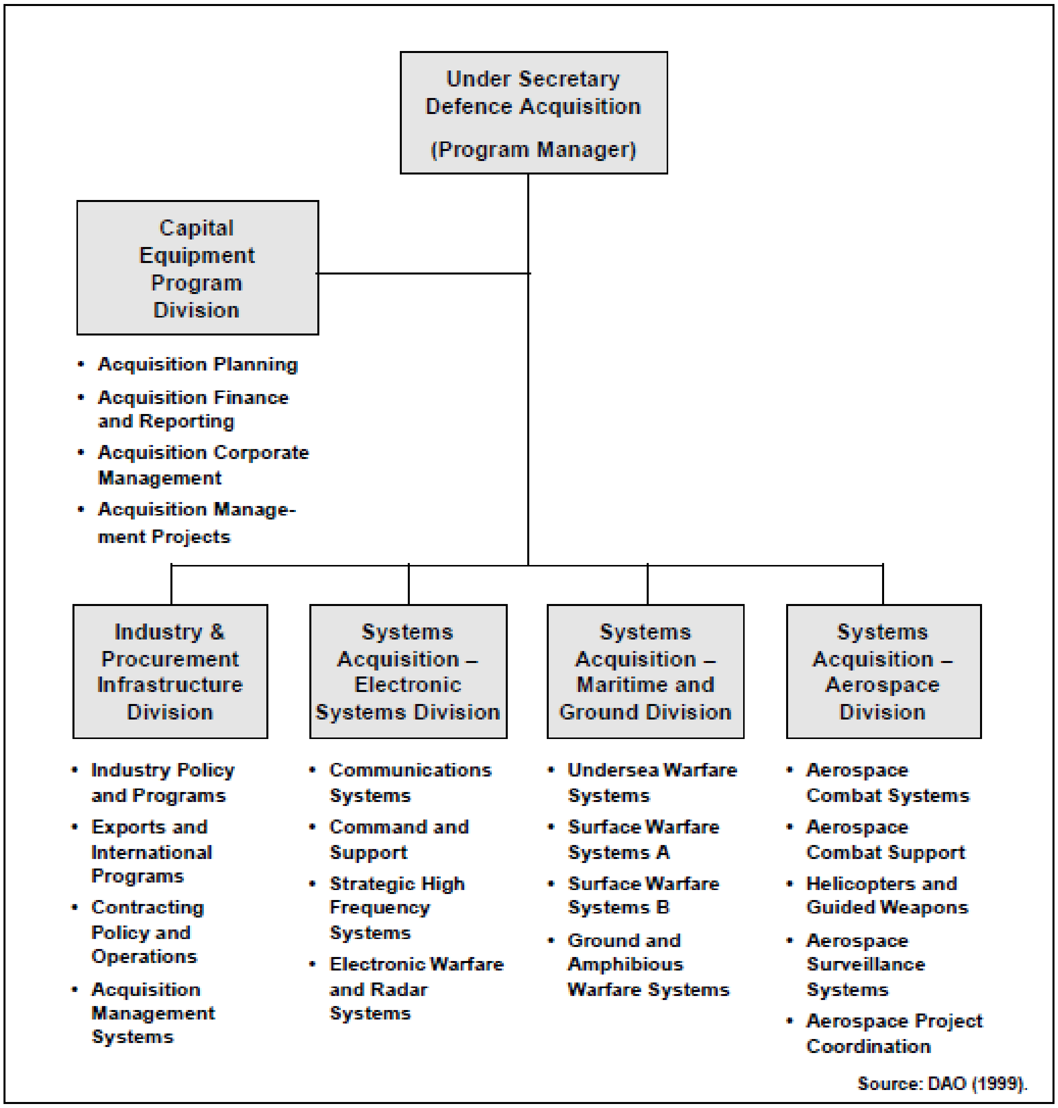


Figure 8. Defense Acquisition Organizational Structure [From: Kausal, 2000, p. 1–41].

Australia's weapon systems acquisition process has three main phases: Pre-project Approval Phase, Approval Phase, and Post-Project Approval Phase. The Pre-Project Approval Phase deals with capability development, mission needs, program definition, analysis of alternatives, acquisition strategy, military priorities, and approval for proposed programs. The Post-Project Approval Phase, also known as the Implementation Phase, asks for bids from industry, evaluates and selects contractors, manages the acquisition and contract, and oversees the weapon systems' acceptance into operational service. See Figure 9 for more detail on Australia's acquisition life-cycle.

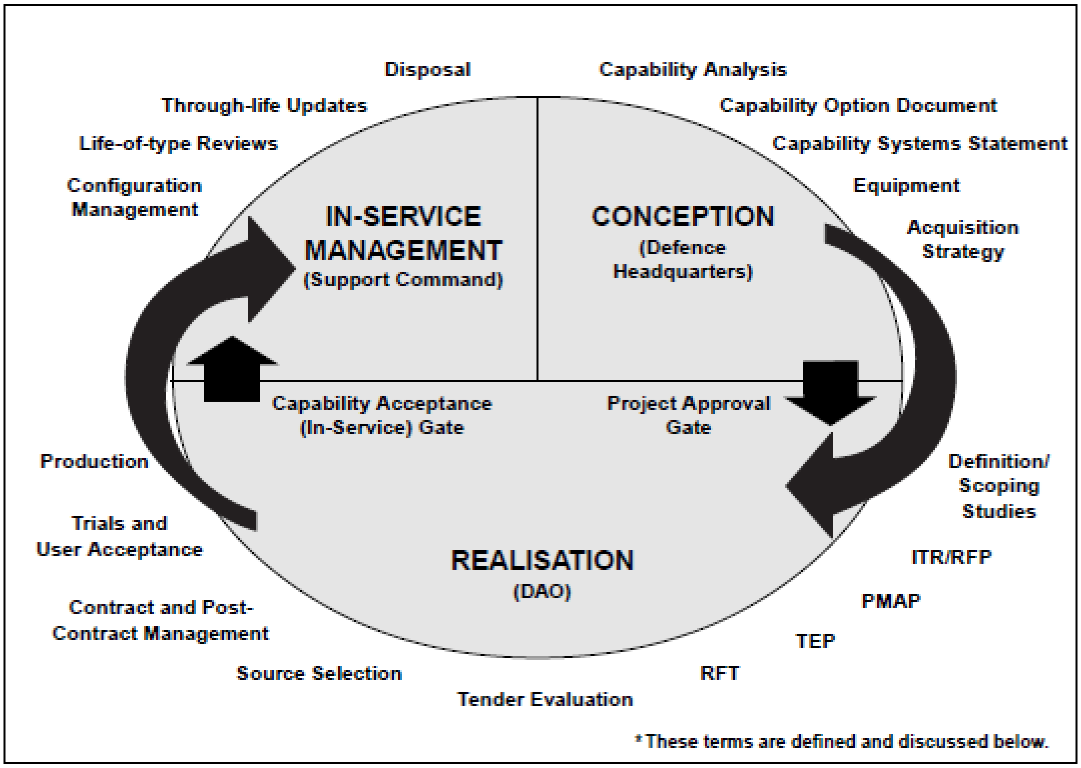


Figure 9. Australia's Acquisition Life-cycle [From: Kausal, 2000, p. 1–49].

Australia's once publically owned defense industry has been privatized as a means to create more efficiency. Foreign competitors are welcomed to bid. However, Australia stipulates certain long-term commitments and investments from these firms. The defense culture has changed tremendously in Australia. Now, local industry is increasingly involved in capability development, capability management, and cost estimates (Kausal, 2000).

6. Japan's Defense Acquisition System

Compared to other countries, Japan has the third largest economy with a population of 127,078, 679 (CIA World Factbook, 2009). Japan has a parliamentary government with a constitutional monarchy. The Japanese Ministry of Defense oversees three military branches: Ground Self-Defense Force, Maritime Self-Defense Force, and Air Self-Defense Force (CIA World Factbook, 2009).

Although Japan's Prime Minister is the head of government, the executive power of the state is held by the Cabinet. The Cabinet is comprised of the Prime Minister and other Ministers of State who are appointed and removed by the Prime Minister. Part of the Office of the Prime Minister is Japan's Defense Agency. This is led by the Director General, who is the Minister of State for Defense (Kausal, 2000). See Figure 10 for more detail on the structure of Japan's Defense Agency.

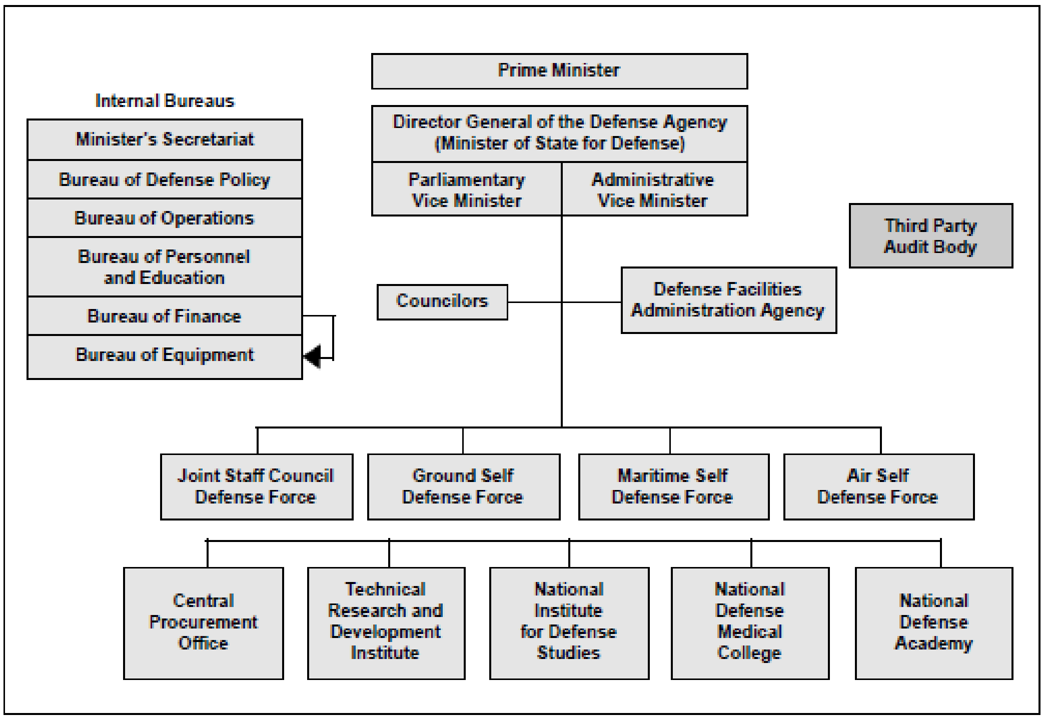


Figure 10. Japan's Defense Agency [From: Kausal, 2000, p. 2–15].

Weapon systems acquisition in Japan is primarily managed by three bureaus: the Bureau of Defense Policy, the Bureau of Finance, and the Bureau of Equipment. The Bureau of Defense Policy is responsible for designing defense policy and programs, conducting trade-off analyses, and defining the military's operational activities. The Bureau of Finance is involved in creating the defense budget and military spending priorities. The Bureau of Equipment is responsible for oversight and management of the acquisition system (Kausal, 2000).

In Japan, mission needs are defined by the individual military branches and proposed to the defense department in the form of new equipment needs or changes to existing systems. At this point, an Operational Requirements Document is prepared and the Research and Development Process begins, which consists of four phases and initializes the acquisition process: Concept Phase, Research Phase, Development Phase, and Operation Phase. The Concept Phase conducts feasibility studies, defines costs, and analyzes technical challenges. The Research Phase identifies technical risks, demonstrates and tests technology, and performs sub-system research. The Development Phase requires the contractor to design the system, build a prototype, and test for performance. If the system performs acceptably, then it is ready for the production phase. However, funding must first be secured and commitment gained from the Defense Agency and others. The Operation Phase begins with operational tests. Once these are successful, approval is given to award contracts for production (Kausal, 2000). See Figure 11 for more information on Japan's acquisition system.

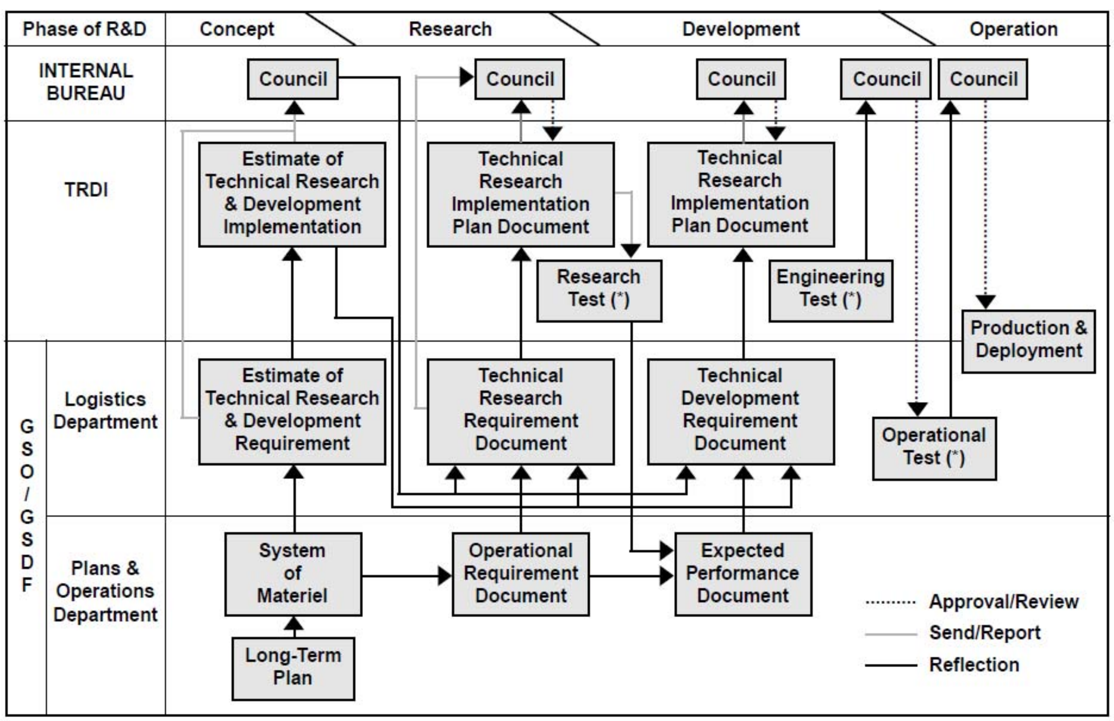


Figure 11. Japan's Acquisition System [From: Kausal, 2000, p. 2–26].

7. South Korea's Defense Acquisition System

South Korea has the 14th largest economy in the world compared to other countries (CIA World Factbook, 2009). It is a republic with a population of 48,508,972. South Korea's military has three branches: Republic of Korea Army, Navy, and Air Force (CIA World Factbook, 2009). The President is elected to a single, five-year term and is the Head of State, Chief Executive, and Commander-in-Chief of the Armed Forces. The Ministry of National Defense is one of the President's responsibilities. It was reorganized in May 1999 (Kausal, 2000). See Figure 12 for the organizational structure of the Ministry Of National Defense.

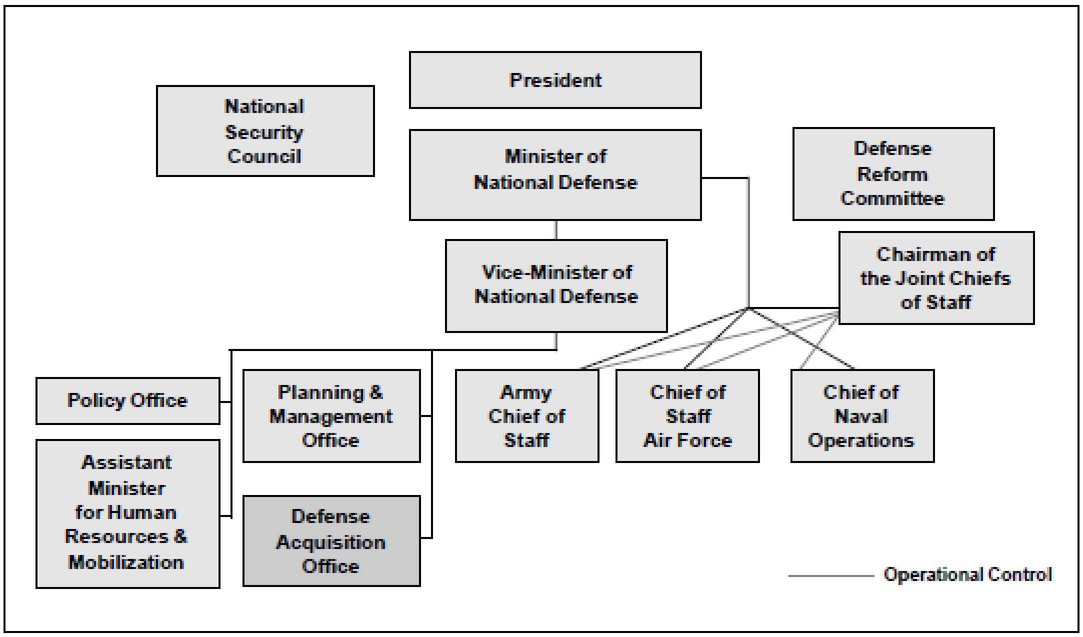


Figure 12. The Republic of Korea's Ministry of National Defense [From: Kausal, 2000, p. 3–4].

The Ministry of National Defense has recently reformed its acquisition system, introducing a new acquisition development structure in February 2000. Korea's acquisition structure consists of the Defense Acquisition Office, the Planning and Management Office, and the Policy Office, all of which fall under the Minister and Vice Minister of National Defense. This new development structure was formed to reduce processes and time, facilitate economical acquisition, and establish clear lines of communication (Kausal, 2000). See Figure 13 for a more detailed view.

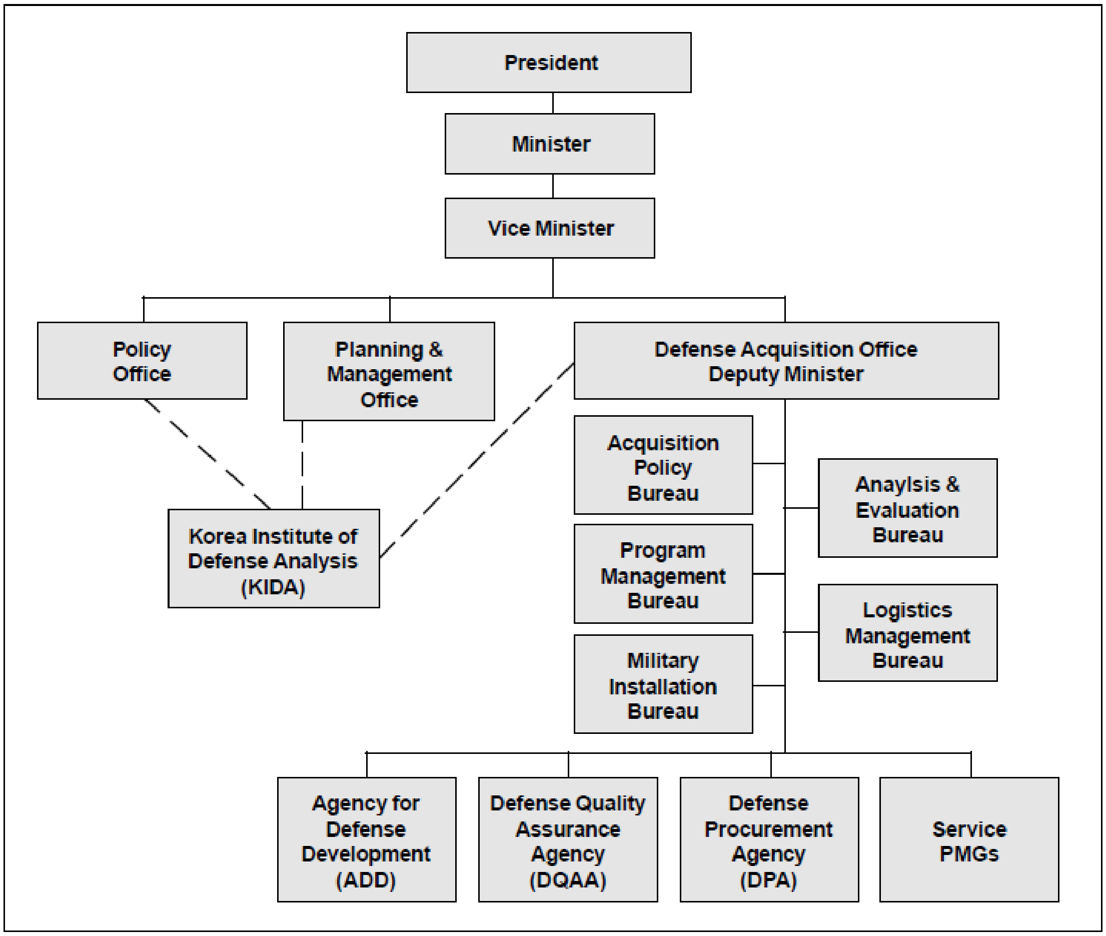


Figure 13. Korea's Acquisition Development Structure [From: Kausal, 2000, p. 3–17]

Requirements for new weapon systems can come from different sources, not just the military branches. However, much like the U.S., each service does propose new weapon systems through the document, Required Operational Capability. Approval of major weapon systems must be obtained by the Joint Chiefs of Staff (JCS). The acquisition process consists of five phases: Planning, Programming, Budgeting, Executing, and Evaluation. The Planning Phase first assesses the threat and then determines the strategy. Requirements are further explored and a Medium-Long Range

Force Requirements Proposal is created. This proposal is evaluated by certain members of the JCS; and if they agree on the proposal, they prepare the Joint Strategic Objective Plan. This is then reviewed by other members of the JCS; and if these members agree, they prepare the Mid-Term Defense Plan and the Defense Acquisition Development Plan. These two plans define the Programming Phase. During the Budgeting Phase, the Defense Budgeting Document is organized. In order to allow more stability within the programs, multi-year funding is requested for the entire project. Once this is approved by the Minister of National Defense, it is submitted to the President's Budget Administration Office in May. This is reviewed by the cabinet and then sent to the National Assembly for review and approval. Budget is usually passed in December. The Execution Phase awards contracts for research and development and for procurement. The Evaluation Phase analyzes completed programs and provides feedback (Kausal, 2000). See Figure 14 for more detail on the Acquisition Process.

Phase	Document	OPR	Purpose
Planning	Force Requirement Proposal LRFRP MRFRP MLRFRP Joint Strategic Objective Plan (JSOP)	Services	Defense Goals Threat Assessment Defense Policies Consolidates/Coordinates Service Proposals
Programming	Defense Acquisition & Development Plan MTDP	DAO/APB PMO (O&S) DAO/APB (Investment)	Define Systems & Equipment to Implement Defense Goals
Budgeting	Defense Budget Document	DAO/APB (Investment) PMO (O&S)	Define Money Needed to Implement
Executing	Defense Budget Allocation Plan	DAO/APB	Money Authorized by National Assembly for Fiscal Year
Evaluation			Analyze Completed Project & Improve System

Figure 14. Korean Ministry of National Defense Acquisition Process [From: Kausal, 2000, p. 3–27].

III. METHODOLOGY

A. CLIOS PROCESS

"When we try to pick out anything by itself, we find it hitched to everything else in the universe." -John Muir

Complex systems with wide ranging economic, social, and political impacts are more common than ever before, yet understanding their true nature and solutions for problems surrounding them is less known. A CLIOS system is one that is Complex, Large-scale, Interconnected, Open, and Socio-technical (Sussman, 2007). Professors and doctoral students in the Engineering Systems Division at MIT developed the CLIOS process for just such systems. It is now taught in the class, "Frameworks and Models in Engineering Systems." Engineering systems are ones with a technical aspect to them, not just economic, political, or social. The CLIOS framework is an iterative process used to study CLIOS systems. It is a systems approach to analyzing and addressing problems by representing the entire system in an integrated form.

Complexity is a key aspect of a CLIOS system (Sussman, 2007). First, structural complexity is an attribute of a system with many interconnected parts. Behavioral complexity is an attribute of a CLIOS system, e.g., it is difficult to predict system behavior. The internal behavior of subsystems and components may be understood, yet the relationship among all of these subsystems and components may be difficult to predict. Nested complexity occurs when a physical or technical system is embedded and interacts with an institutional sphere. The institutional sphere is a system of its own, which may experience structural and behavioral complexity. It is this interaction of the two systems—physical and institutional—within one bigger system, which creates nested complexity. Finally, evaluative complexity refers to the involvement of multiple stakeholders with multiple perspectives, expectations, and values (Sussman, 2007).

In addition to being complex, CLIOS systems are large-scale, interconnected, open, and sociotechnical (Sussman, 2007). Large-scale means these systems have a large impact, are long-lived, and usually are large-scale in geographic sense. A CLIOS system is interconnected meaning it is interrelated with other sociotechnical systems. Sussman (2007) gives the example of the relationship among transportation systems, energy systems, and the global climate systems as being interconnected. Above and beyond the technical aspect, a CLIOS system is also open, meaning it consists of social, political, and economic characteristics. Finally, a CLIOS system is sociotechnical in that it is not solely technical, nor is it exclusively social. See Figure 15 below.

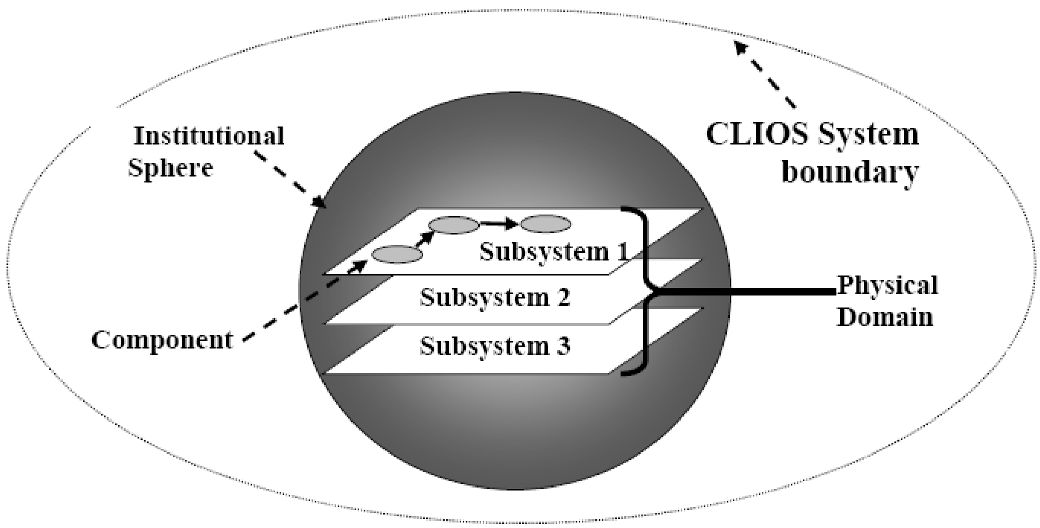


Figure 15. CLIOS System—Physical Domain with Subsystems Embedded in an Institutional Sphere

B. CLIOS STRUCTURE

The basic structure of the CLIOS analysis process is three stages encompassing 12 steps (Sussman, 2007) (See Figure 16 below). The three stages include (1) Representation; (2) Design, Evaluation, and Selection; and (3) Implementation. The twelve steps make up the process with Steps 1 through 5 falling within the Representation stage; Steps 6 through nine in the Design, Evaluation, and Selection stage; and Steps 10–12 in the Implementation stage:

1. Describe CLIOS System: Checklists & Preliminary Goal Identification
2. Identify Subsystems in Physical Domain & Groups on Institutional Sphere
3. Populate the Physical Domain & Institutional Sphere
4. a.) Describe Components and b.) Describe Links
5. Transition from Descriptive to Prescriptive Treatment of System
6. Refine CLIOS System Goals & Identify Performance Measures
7. Identify & Design Strategic Alternatives for System Improvements
8. Identify Important Areas of Uncertainty
9. Evaluate Strategic Alternatives & Select "Bundles"
10. Physical Domain / Subsystems
11. Institutional Sphere
12. Evaluate, Monitor, & Adapt Strategic Alternatives for CLIOS System

(Sussman, 2007)

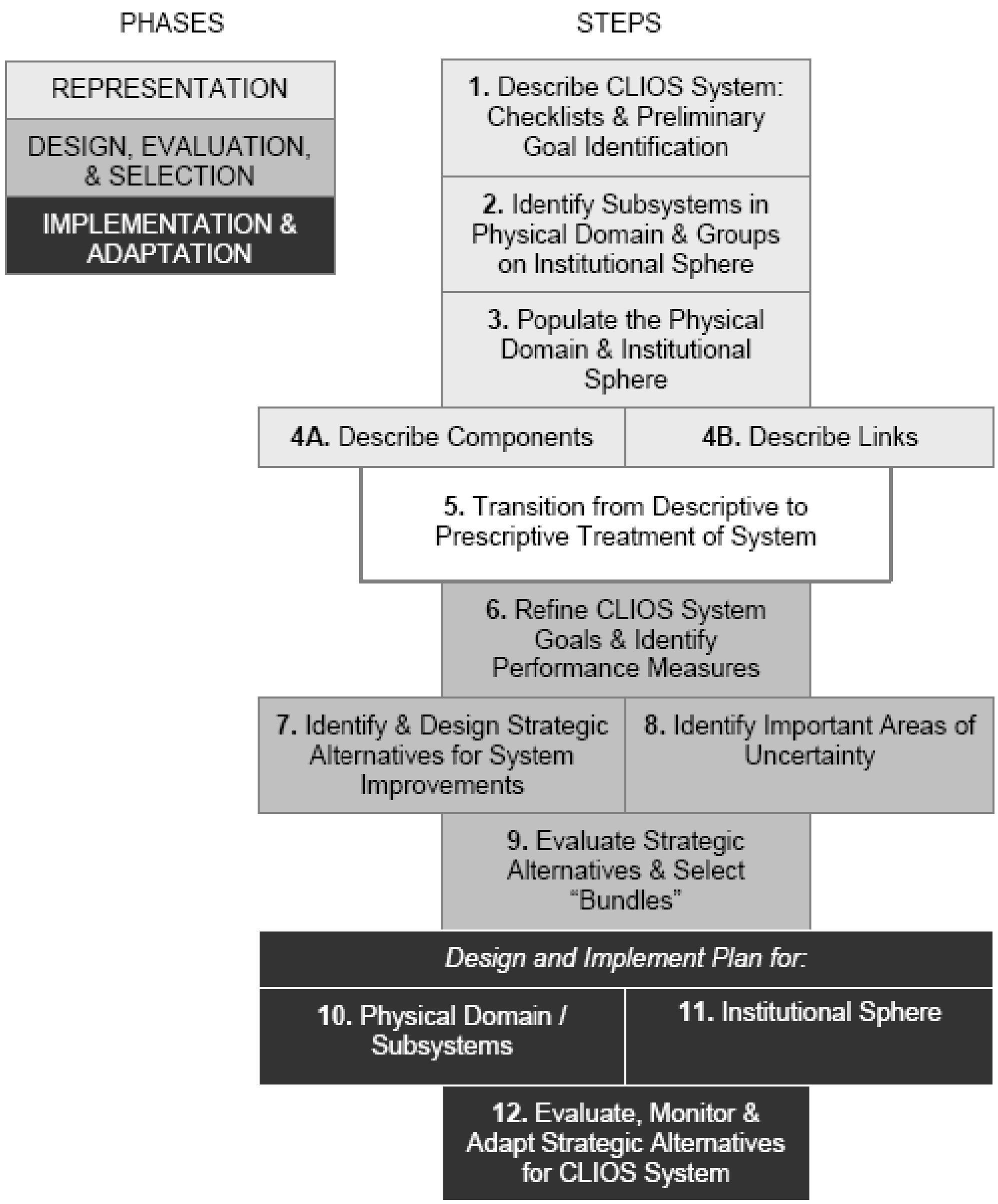


Figure 16. CLIOS Process (From: Sussman, 2007, p. 15)

The CLIOS Process requires analysts to take a strong systems-thinking approach. It provides a framework for understanding systems holistically and more clearly (Sussman, 2007).

1. Representation Stage

The purpose of the representation stage is to explore and come to an understanding of the structure and behavior of the system being analyzed (Sussman, 2007). This stage primarily utilizes diagrams to illustrate the system, subsystems, institutional sphere, and the interrelationships among them. At this point, there is a common understanding of the system, which leads to better understanding the issues and goals.

The representation stage encompasses the first five steps to illustrating and interpreting the system. Step 1 requires checklists and preliminary goal identification (Sussman, 2007). It is during this step that the CLIOS System is preliminarily bounded. The first checklist, the characteristics checklist, may include the following:

> Temporal and geographic scale of the system, (b) the core technologies and systems, (c) the natural physical conditions that affect or are affected by the system, (d) the key economic and market factors, (e) important social or political factors or controversies related to the system and (f) the historical development and context of the CLIOS System. (Sussman, 2007, p. 19)

The second checklist requires describing opportunities, issues, and challenges (Sussman, 2007). These will be used in Stage 2 to determine improvements through strategic alternatives. The final checklist establishes preliminary system goals, which usually relate to the results from the second checklist (Sussman 2007). See Figure 17 below.

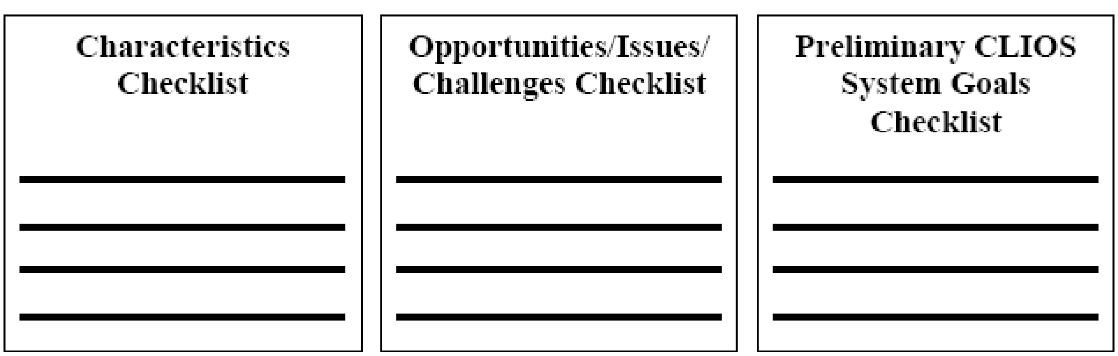


Figure 17. CLIOS System Checklists (From: Sussman, 2007, p. 20)

Since the CLIOS framework is an iterative process, system boundaries may expand or contract or even be redefined as the analysis progresses (Sussman, 2007).

Step 2 of the representation stage requires the analyst identify subsystems in the physical domain and groups in the institutional sphere (Sussman, 2007). There are three main activities in Step 2: (1) defining the major subsystems in the physical domain, (2) determining the main actor groups in the institutional sphere, and (3) defining the interrelationships between these on a macro-level. There are various ways to accomplish this. One is by using the information gathered in Step 1 and grouping the issues into categories. Another is by classifying the subsystems by common functions, technological aspects, or relationships to other actor groups in the institutional sphere. For the physical domain, the physical system is broken out into subsystems, and the linkages among the systems are identified. This may be difficult to develop but valuable due to the better understanding of the system structure and behavior. For the institutional sphere, the information for the major actor groups can be obtained from the information gathered in Step 1 (Sussman, 2007).

While Step 2 requires identifying subsystems in the physical domain and actor groups in the institutional sphere, Step 3 requires populating the physical domain and institutional sphere (Sussman, 2007). For the physical domain, early CLIOS diagrams are formed to detail each of the subsystems with components and links. There must be a balance between adding too much detail and oversimplifying the subsystem and components. The institutional sphere is also populated with individual actors within major actor groups, along with the links among them.

Step 4A requires describing these components and actors in the physical domain and institutional sphere respectively that were earlier identified and diagramed (Sussman, 2007). Within the physical domain, the individual components are defined and categorized into one of three types of components: regular components, policy levers, or common drivers. Regular components are the most common and can refer to complex structures such as economic growth or concepts such as congestion. Policy levers are components that are influenced by decisions made by the actors in the institutional sphere. Common drivers are components that are shared across subsystems. In addition, there can be external factors, which may be a regular component or common driver. To differentiate these in the diagram, CLIOS has three shapes and one shading. See Figure 18.

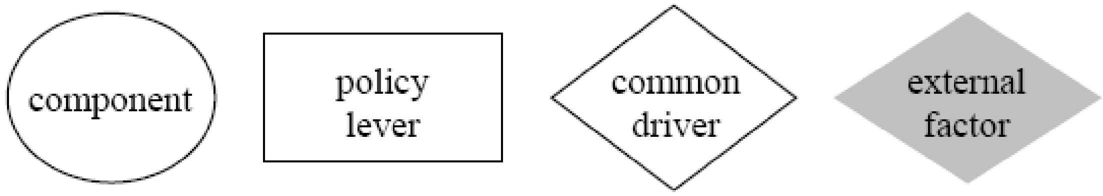
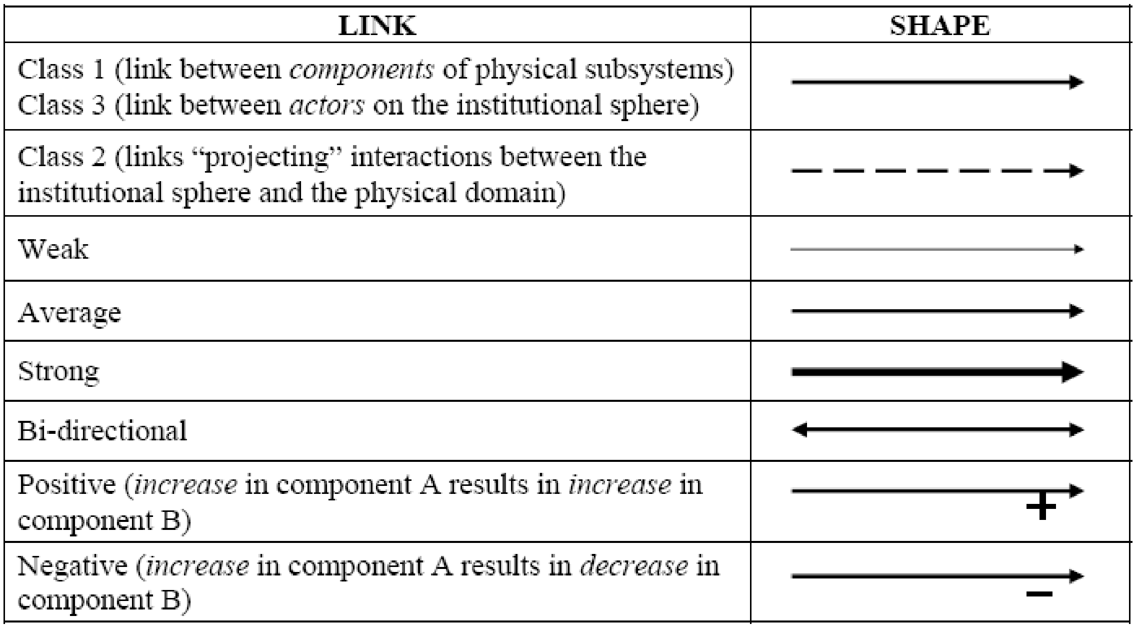


Figure 18. Suggested CLIOS System Diagram Component Shapes (From: Sussman, 2007, p. 24)

The actors in the institutional sphere are also described as part of Step 4A. It is important to identify characteristics such as their influence over subsystems, their relevance to the subsystems, their knowledge and resources, their agenda concerning strategic alternatives, and other relevant information (Sussman, 2007).

Step 4B requires the analyst to describe the links denoting directionality of influence, extent of influence, timeframe of influence, and uncertainty (Sussman, 2007). The CLIOS process has three classes of links: (1) Class 1: links between components, (2) Class 2: links between components and actors, and (3) Class 3: links between actors. Figure 19 identifies suggested link shapes for CLIOS diagrams.



LINK	SHAPE
Class 1 (link between *components* of physical subsystems) Class 3 (link between *actors* on the institutional sphere)	
Class 2 (links "projecting" interactions between the institutional sphere and the physical domain)	
Weak	
Average	
Strong	
Bi-directional	
Positive (*increase* in component A results in *increase* in component B)	+
Negative (*increase* in component A results in *decrease* in component B)	−

Figure 19. Suggested Link Shapes (From: Sussman, 2007, p. 27).

The final step in the representation stage is Step 5, which is a transition from descriptive to prescriptive treatment of the system. At this point, the general structure of the system has been determined, and the behavior of the components, actors, and links has been described. Before proceeding to Stages 2 and 3, the analyst should reflect and ask questions such as (1) are there strong interactions within or between subsystems or actors? (2) which components are influenced by many different actors? and (3) are relationships between actors full of conflict or cooperation? Many more questions should be asked to better understand the system as a whole before moving to the next stages (Sussman, 2007).

2. Design, Evaluation, and Selection Stage

Stage 2—Design, Evaluation, and Selection—moves from stage one where initial structure and behavior were studied to the next stage where system complexity is examined in greater depth to find leverage points for improvement (Sussman, 2007). At this stage, strategic alternatives are developed. Where stage one was qualitative, this stage is more quantitative using models for comparing strategic alternatives.

Stage 2 encompasses Steps 6 through 9 to design, evaluate, and select (Sussman, 2007). During Step 6, the analyst refines the CLIOS system goals, which were initially created in stage one, and identifies performance measures. Performance measures identify progress made from the current state of the system to the desired future state as determined when refining the goals. Performance measures can be very difficult to define and prioritize.

In Step 7, the analyst identifies and designs strategic alternatives for CLIOS system improvement (Sussman, 2007). Once goals and performance measures are established, the natural progression is to find areas of improvement. Identifying strategic alternatives requires creative thinking and brainstorming. Strategic alternatives are physical, policy-driven, or actor-based. A physical strategic alternative may be derived after bottom-up systems engineering approach is taken to analyze the physical domain, subsystems, and components. A policy-driven strategic alternative may be derived after analyzing how various policies influence the system. Finally, an actor-based strategic alternative may be derived after evaluating institutional arrangements.

Step 8 requires flagging important areas of uncertainty (Sussman, 2007). This step may be conducted in parallel with Step 7 when identifying strategic alternatives for performance improvement. Information gained in Steps 1 through 6 may provide insights into uncertainties. Links with strong interactions may be an area of uncertainty. Conflict between actors may be another uncertainty. Common drivers may have strong influences and, therefore, be another area of uncertainty. Methods for determining uncertainty can be quantitative or qualitative such as risk assessments or scenario planning.

The final step in stage two, Step 9, is to evaluate strategic alternatives and bundles (Sussman, 2007). Here the strategic alternatives determined in Step 7 are evaluated using models developed in Step 6. Additional models may be necessary. Each of the strategic alternatives is evaluated by the impacts it has on the CLIOS system. Trade-off analysis may also be used to compare strategic alternatives. It is rare for a single strategic alternative to be chosen and implemented due to the complexity of CLIOS systems. Usually, one alternative will not meet the CLIOS system goals. Therefore, strategic alternatives may be combined into bundles.

3. Implementation Stage

The final CLIOS process stage is implementation (Sussman, 2007). Although bundles of strategic alternatives have been chosen, implementation of those alternatives may have hurdles of its own. The implementation stage designs a guide for implementing the alternatives in Steps 10 through 11. Step 12 is the final step in the implementation stage and the CLIOS Process as a whole.

Step 10 focuses on designing and implementing the plan for the physical domain and subsystems (Sussman, 2007). Many questions arise and must be answered during this phase before the plan is fully developed. Are there enough resources? Is the time-frame for meeting system goals reasonable? How do the strategic alternatives fit with each other? How do failures in meeting targets affect the implementation? Which actor(s) will implement, monitor, and enforce which strategic alternative? Attention must be given to the performance measures and trade-offs.

Step 11 focuses on designing and implementing a plan for the institutional sphere and may be conducted in parallel with Step10 (Sussman, 2007). Some of the strategic alternatives developed in Step 9 may include actor-based changes and must be included in the overall implementation plan. The analyst must understand the actor(s), the actor's goals, and the changes that will affect the actor(s). There may be opponents of these alternatives with resistance to implementation.

Step 12 ensures that the implemented alternatives are monitored and evaluated both in the short- and long-term (Sussman, 2007). Although the strategic alternatives are evaluated in Step 9, it is impossible to know their true impacts on the system as a whole until after implementation. It is possible to have unanticipated and/or indirect side effects. During Step12, outcomes are observed, and necessary modifications are made.

C. CONCLUSION

The CLIOS Process is iterative in nature. Goals and performance measures set in greater depth in Step 6 may require the analyst to return to Step 1 to review and challenge the preliminary goals. In Step 7 when identifying and designing strategic alternatives, the analyst may need to revisit Step 2 and refine or add additional subsystems and actors. Again, when flagging uncertainties in Step 8, Step 2 may be revisited and revised. Finally, in Step 12 where the strategic alternatives are monitored for impacts and outcomes, it may be necessary to return to Steps 5, 7, 8, and/or 9. See Figure 20 for the iterative process.

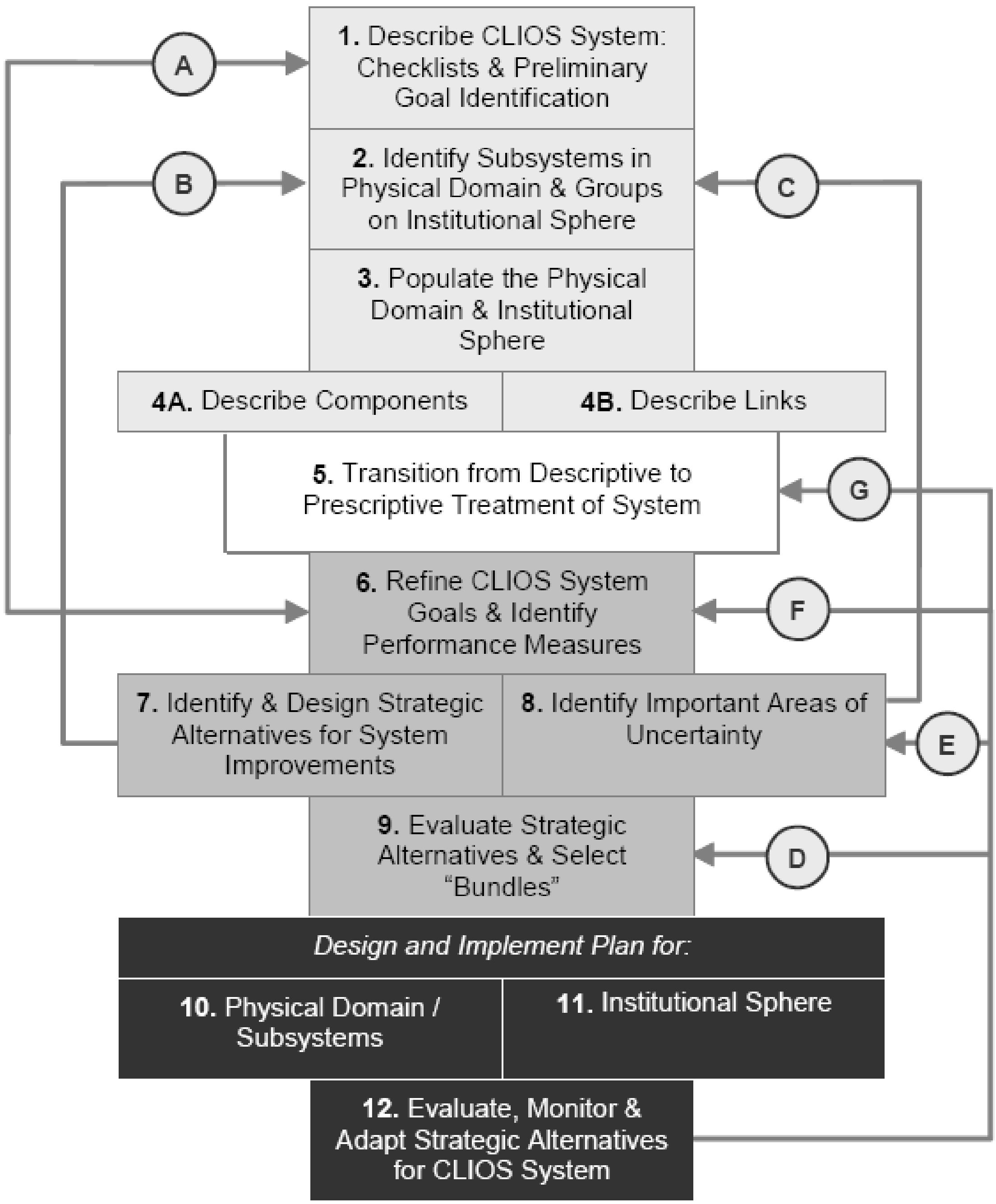


Figure 20. Iteration in the CLIOS Process (From: Sussman, 2007, p. 16)

IV. CLIOS STAGE 1 REPRESENTATION—MAJOR DEFENSE ACQUISTION SYSTEM

A. INTRODUCTION

The first stage of the CLIOS process—Representation—is the first order for understanding the CLIOS System, in this case the U.S. major defense acquisition system. The key functions of this stage are (a) to begin to understand the major defense acquisition system as a whole and (b) to establish preliminary goals for this system. The outputs for this stage are (1) system description, (2) issue identification, (3) goal identification, and (4) a structural representation.

The CLIOS framework is an iterative process. As an analyst moves through the stages and obtains a greater understanding of the system, s/he will return to previous stages or steps to modify, refine, and improve. The complex nature of the CLIOS system requires this.

This chapter presents a partial CLIOS application representing the physical domain of the U.S. major defense acquisition system nested within an institutional sphere. The first four steps of the CLIOS Process, which are found in Stage 1, are applied to the major defense acquisition system.

B. STEP 1—DESCRIBE THE SYSTEM: CHECKLISTS AND PRELIMINARY GOAL IDENTIFICATION

Step 1 is the initial system description and preliminary goal identification. The CLIOS Process facilitates system description with a series of checklists for a high-level assessment. There are three checklists: Characteristics Checklist, Opportunities / Issues / Challenges Checklist, and Preliminary CLIOS System Goals Checklist. Refer back to Figure 17 on page 55 for more detail on checklists. These items may range from detailed descriptions to high level bullet points. The key idea in Step 1 is to initially frame the system. Although much of the literature review in Chapter II covers many of the items for the checklists in Step 1, below is a summation of the key points.

1. Characteristics Checklist

The Characteristics Checklist has a series of questions to facilitate the development of the checklists.

a. What is the Temporal and Geographic Scale of the System?

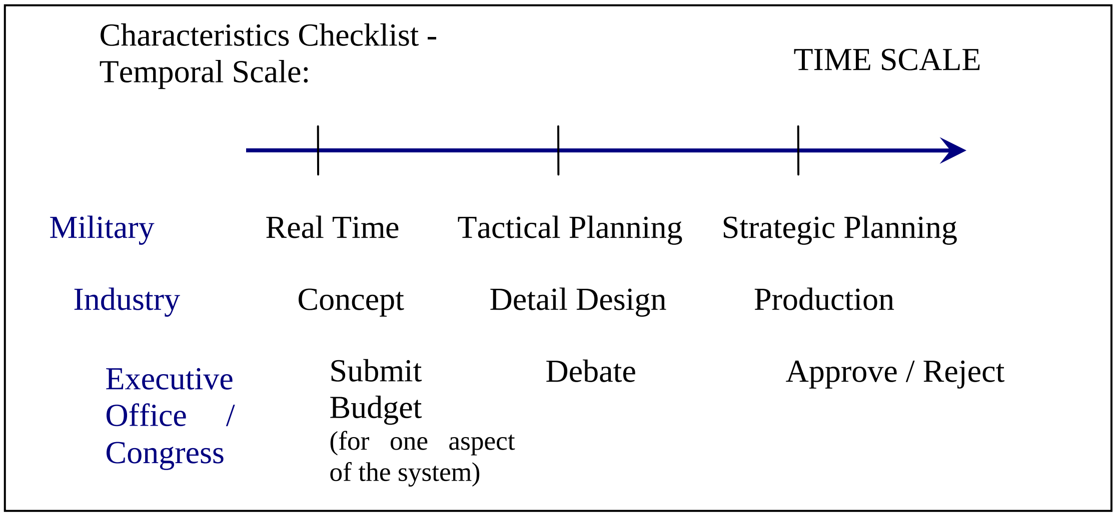


Figure 21. Temporal Scale

Depending on whose perspective is used (see Figure21), the time scale for the major defense acquisition system may be different. DoD spends three years of planning before submitting the request to be added to the President’s budget. For the defense industry, from concept to delivery, acquiring a major weapon system could take well over 10–15 years depending on the maturity level of technology.

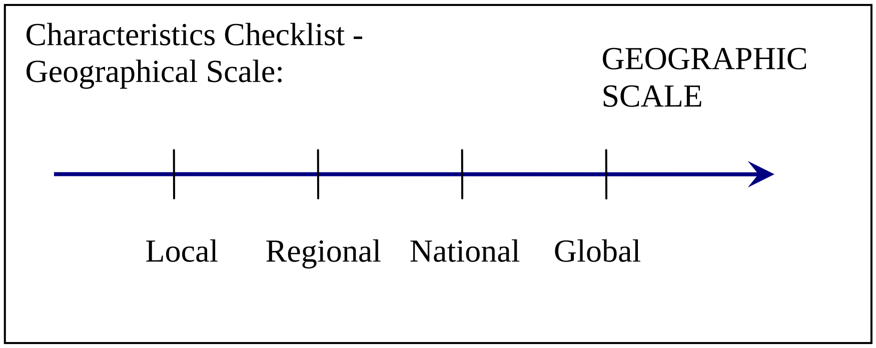


Figure 22. Geographic Scale

The weapon systems are designed and produced all over the U.S., including prime and subcontractors, vendors, program executive offices, stakeholders, etc. In addition, the actual weapons systems are utilized on a local, regional, national, and global basis (See Figure 22 above).

b. What are the Core Technologies and Systems?

Characteristics Checklist continued -
Some Core Technologies and Systems:

- Software
- Laser
- Radio
- Physics
- Autonomous
- Physics

- Airborne Laser (ABL)
- Global Hawk Unmanned Aircraft System
- Kinetic Energy Interceptors
- DDG 1000 Destroyer
- E-2D Advanced Hawkeye
- Terminal High Altitude Area Defense (THAAD)
- And many more…

Figure 23. Core Technologies and Systems

By 2007, DoD had 95 major defense acquisition programs in its portfolio (GAO, 2008). Major weapon systems include but are not limited to the list above. These systems require advanced technology. Years ago, DoD bought hardware, e.g., ships, aircraft, etc., which were controlled by the warfighter. Today, the systems are advanced and complex with integrated software controlling most of the core subsystems within the platform.

c. What are the Key Economic and Market Issues?

Industrial base. Nearly 25 years ago, defense programs had over 20 prime contractors competing for multiple programs every year (DAPAP, 2005). Today there are four dominant prime contractors competing for fewer and fewer programs. Contractors have had to reduce plant capacity or merge with others. Although it is important for competition to play a role, fewer prime contractors and lower productions mean higher costs. Also, since one prime contractor cannot monopolize the market, contracts are usually shared because it is necessary to keep the workforce and industry knowledge current with more than one company.

Workforce. Both the workforce producing the actual weapon systems and the workforce involved as military or civilians working the acquisition side are crucial to the system. Congressmen lobby for certain programs, which are produced in their states. The employment of their constituents is a key to economic development in their area.

Inflation. Many of the GAO reports reviewed in Chapter II cited inflation as being a key concern for increase in cost estimates.

d. Are There any Important Social or Political Issues or Controversies that Relate to this System?

Pork barrel or Earmarks: As mentioned above under workforce, congressmen have an agenda that may be different from the need or the good of the whole. It is in their interest and that of their constituents to receive defense contracts for companies in their area or state for economic and/or sustainable development. Therefore, there is an incentive for them to lobby for programs that benefit them but may not benefit the nation as a whole.

Unrequested weapons. Congress is known for adding items to the budget that were not necessarily requested by DoD. For example, this year (2009) Secretary of

Defense Robert Gates deleted the F-22 Raptor Air Dominance Fighters from the budget. However, Congress threatened to add them.

Immature technology. Although there is a policy for not approving and funding projects until the technology has been demonstrated, programs continually receive funding with unproven and immature technology, requiring more funds later in the process and, of course, affecting schedule and performance.

International security environment. The wars in Iraq and Afghanistan have demonstrated we are fighting a different kind of enemy that requires different strategies and weapons.

e. What is the Historical Development and Context of the Major Defense Acquisition System?

The U.S. acquisition system has been experiencing problems for more than a century and has been undergoing reform for more than half a century. The planning, programming, and budgeting system was instituted in 1962 when Secretary of Defense Robert McNamara decided to run the government like a business (Kausal, 2000). There has been a long history of inaccurate estimations, requirements creep, and poor program management.

f. What are the Policy Questions that Need to be Addressed?

Funding. For stability, these major defense acquisition systems need long-term commitment, not year-to-year budget approval. Commitment to funding creates stability for the contractors, allowing them to focus on delivering capabilities rather than gaining incremental funding. This funding commitment to programs allows program managers to identify unknowns as high risks early without criticism or loss of funding.

Technology. Although there are policies in place to avoid the risk of acquiring major defense systems without mature technologies, countless programs continue with unproven technology.

Oversight vs. Accountability. DoD has a complicated acquisition system emphasizing oversight of programs rather than emphasizing accountability by the contractors.

Cost estimation. The process for estimating costs must be addressed. Whether the estimates are low to not cause "sticker shock" and gain initial approval or whether there is not enough knowledge of the program to understand the actual costs, the system must be improved.

2. Opportunities, Issues, and Challenges Checklist

This part of Step 1 captures aspects of the major defense acquisition system that later, in Stage 2, will be used to establish strategic alternatives. Information gathered in the Characteristics Checklist will be used as well.

Cost, Performance, Schedule. Historically, cost and schedule have been an issue since with military acquisitions since the Civil War (DAPAP, 2005).

Technology. The U.S. has been a leader in military technology. However, it costs money and time to develop these technologies.

Cost. There is no standard, consistent and coherent cost tracking system that is actually used.

Agendas. There are conflicting values among the acquisition community. As mentioned above, congressmen have an agenda that may be different from the need or the good of the whole. Industry would like to sell more programs and be paid to develop more advanced technology. The military branches have a desire for new, technologically advanced weapon systems. The U.S.'s fundamental strategy has been to deliver lethal violence beyond the enemies' capability to withstand or bear. These advanced systems provide that capability. In addition, with the all-volunteer force, U.S. military branches are small. Therefore, the U.S. does not want to repeat the Korean or WW2 wars. The U.S. forces are currently stretched in Iraq. The advanced weapon systems enabled rapid defeat. However, holding on to "victory" nearly broke the U.S. The issues are not well resolved between political and military interests.

Threats. There are changes in the way war is handled–engaging different types of enemies requires different weapons and tactics. In the past, there were well-known, well-defined threats. Today, there is no single, well-defined threat.

Funding / Stability. Although many of the programs require long-term commitment, the budgeting process is based on short-term decision making. Long-term cost increases are acceptable in order to achieve short-term budget savings.

Economic. The major defense acquisition system is an economic engine employing hundreds of thousands across the nation, yet dependent on the economy.

Value. In the past, the U.S. has focused on the continuous fielding of systems with the best possible performance, not necessarily focused on the best overall value for money.

3. Preliminary Major Defense Acquisition System Goals Checklist

- Provide the best, necessary capability to the warfighter to perform his/her job successfully for the best value.
- Control cost, schedule, and performance.

Step 1 begins to layout the full range of the system. The purpose of Step 1 is to highlight the main issues, identify important problems and possible causes, and provide a preliminary bounding of the system. This step helps determine what subsystems and components will be included, as well as important links. This is an iterative process. Later stages may require returning to stage one due to initially framing the system incorrectly. It is likely important aspects have been left out or only partially represented.

C. STEP 2—IDENTIFY SUBSYSTEMS IN PHYSICAL DOMAIN & GROUPS ON INSTITUTIONAL SPHERE

Step 2 of stage one requires the analyst to identify the major subsystems in the physical domain and the major actor groups on the institutional sphere. The major subsystems within the physical domain can be technical, natural, economic, social, and political. The major actor groups on the institutional sphere are the ones who are affected by the subsystems within the physical domain, who attempt to influence those subsystems, and/or who "worry" about them (Sussman, 2007).

For the physical domain, one logical approach to identifying subsystems is using the ones already defined by DoD: the Planning, Programming, Budgeting, and Execution (PPBE) system, the Joint Capabilities Integration and Development System (JCIDS), and the DoD 5000.02 Acquisition Process.

Identification of the subsystems within physical domain:

- Budget (PPBE)
- JCIDS
- Defense Acquisition System

As stated in Chapter II , the PPBE is how the DoD allocates its resources. "It's how DoD, and their contractors, manage to stay within their fiscal budget while they follow the Secretary of Defense's policy, strategy, and goals" (DAU, 2009). The PPBE process overlaps with and supports the acquisition process by providing feedback and adjustments as needed during the execution phase. JCIDS key role is identifying required capabilities for the warfighters in support of national defense strategies. It is the mechanism for requirements generation and supports the Joint Requirements Oversight Council (JROC). The JCIDS process supports the acquisition and PPBE processes by identifying capability needs and associated performance criteria in order to develop and produce the necessary weapon systems. Finally, the defense acquisition system is the management process that guides all DoD acquisitions programs, including major defense programs. Figure 24 demonstrates how these three entities interact for major weapon systems acquisition. For more detail, go the Defense Acquisition University's website, https://acc.dau.mil/ifc/.

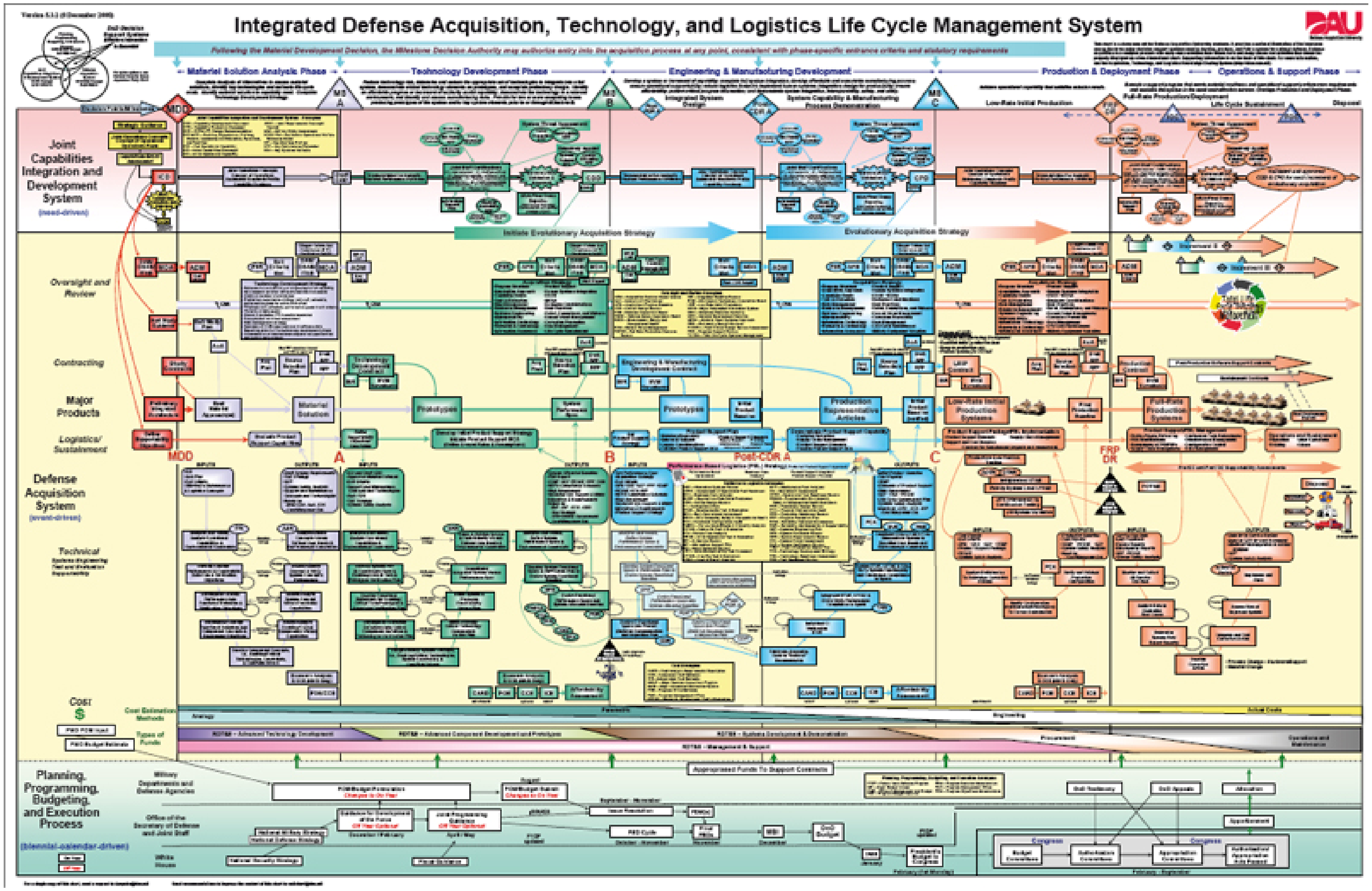


Figure 24. Integrated Defense Acquisition (From: DAU website, https://acc.dau.mil/ifc/)

Although the physical domain has previously been identified and mapped by the Defense Acquisition University, these subsystems alone do not explain the complexity or describe the major defense acquisition system as a whole. There are major actor groups that have influence over or are influenced by the subsystems.

Initial identification of major actor groups on the institutional sphere:

- Congress
- Industry
- DoD
- Military (Individual branches)
- Executive Branch
- U.S. public
- Security Threats

Due to the iterative nature of the framework, more major actor groups may be identified at other times during the CLIOS Process.

D. STEP 3—POPULATE THE PHYSICAL DOMAIN & THE INSTITUTIONAL SPHERE

Step 3 requires populating the physical domain and institutional sphere for the major defense acquisition system and identifying interactions between the two. See Figure 25.

Each of the subsystems within the physical domain is layered and includes influences from the institutional sphere. There is overlap among the PPBE, JCIDS, and Acquisition subsystems.

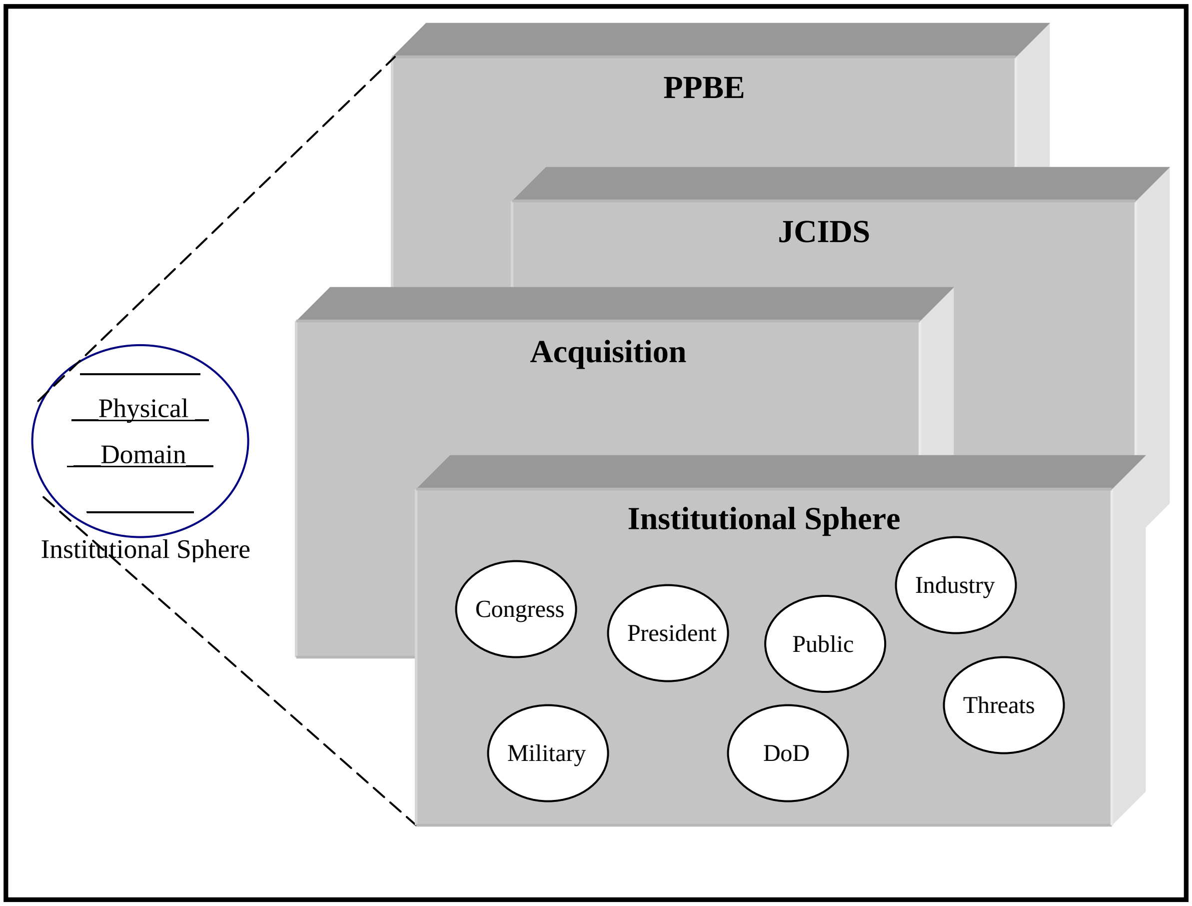


Figure 25. Major Defense Acquisition System—Layering of Subsystems and Institutional Sphere

Within the physical domain, there is overlap and links between the subsystems. Inside the institutional sphere, there is much interaction among the major actor groups. Furthermore, there are many links among the major actor groups in the institutional sphere and the major subsystems in the physical domain. See Figure 26 for a macro-level view of the links among the major actor groups within the institutional sphere and links among the major actor groups and the subsystems in the physical domain.

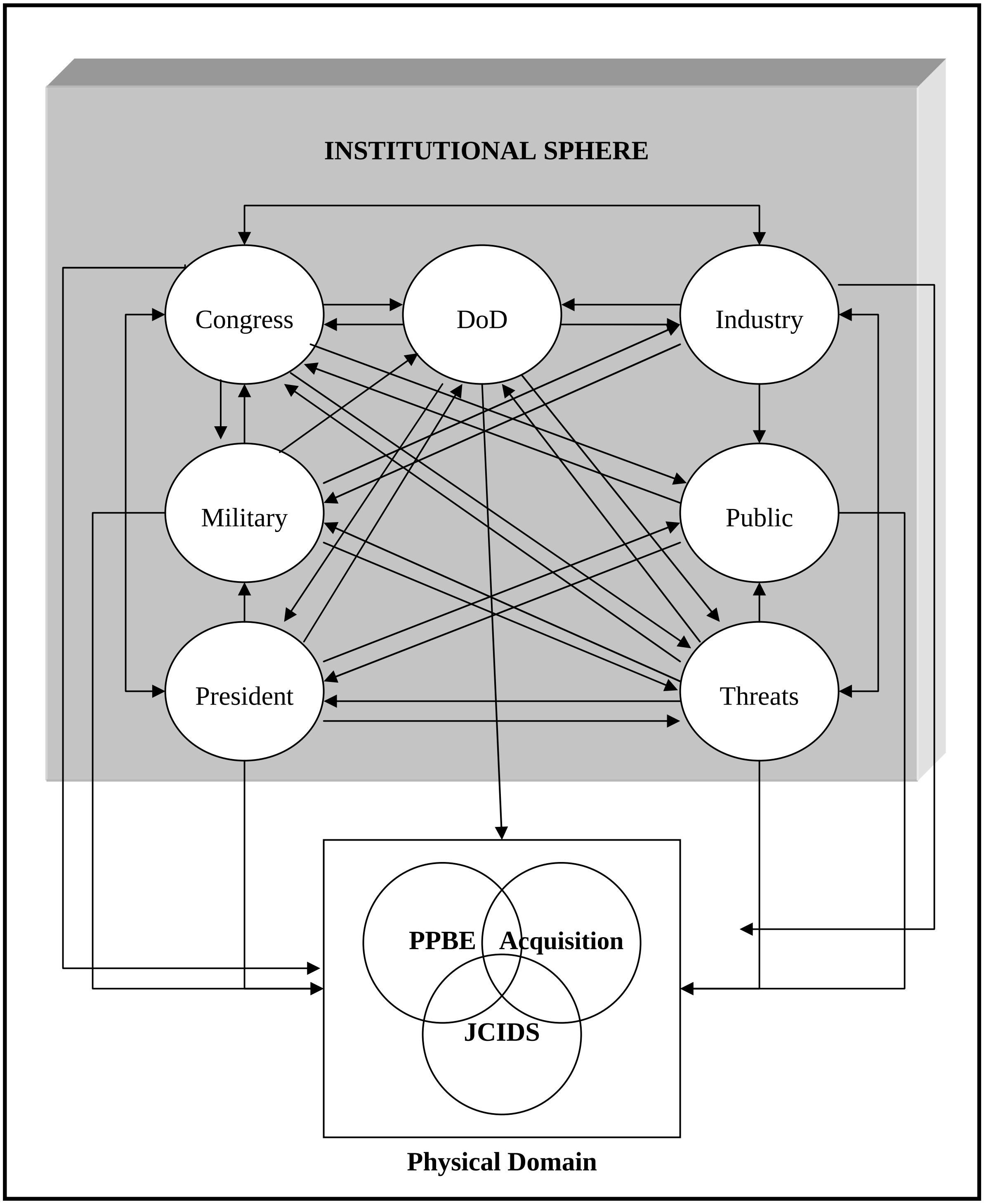


Figure 26. Major Defense Acquisition System—Links Between Institutional Sphere and Physical Domain

E. STEP 4—DESCRIBE COMPONENTS AND LINKS

In the final step of the representation stage, Step 4, the analyst describes the components in the physical domain, the actors in the institutional sphere, and the links among them. Within the physical domain, there are three subsystems: PPBE, JCIDS, and Defense Acquisition System. These three subsystems were designed to assist senior decision makers within the major defense acquisition system. They interact with each other, as well as operate separately. These three systems have been previously defined in both Chapter II and earlier in the fourth chapter. These subsystems have been identified by DoD as major decision-support systems.

1. Physical Domain—Planning, Programming, Budgeting, and Execution (PPBE)

The PPBE is the system used by the DoD to create their portion of the President's budget. This is DoD's strategic planning, program development, and resource allocation process. PPBE has links to both JCIDS and the acquisition system. It supports JCIDS with documents and training. It supports the acquisition system by understanding Security Threats and providing feedback during the execution phase. PPBE is a part of DoD that works with Military, Congress, and the President and employs U.S. civilians.

2. Physical Domain—Joint Capabilities Integration and Development System (JCIDS)

The Joint Chiefs of Staff, under DoD, created JCIDS to identify gaps in military needs and generate requirements. It interacts closely with the acquisition system to integrate capabilities in the acquisition system. The system is influenced by the Military and its needs, by Security Threats, and by Industry's advancement of technology. The product influences Congress and the President's decision concerning the need and funding for the major defense systems.

3. Physical Domain—Defense Acquisition System

The Defense Acquisition System is the management process that guides all DoD major defense acquisition programs. It provides the policies that govern the defense acquisition programs. Major defense acquisition programs progress through a series of milestones associated with major phases of the program. It guides DoD personnel as well as Industry and Military. Congress is updated on the progress of these programs.

The major actors within the institutional sphere of the major defense acquisition system are Congress, DoD, the Military, the Executive Branch, Industry, U.S. Public, and Security Threats.

4. Institutional Sphere—Congress

Congress has two major responsibilities when working within the major defense acquisition system: legislative process and the oversight function. Without Congress, there would be no major defense programs and no money to buy major weapon systems. Without major defense programs, there would be no national defense or jobs surrounding national defense, which includes military and civilians across the world. Both the Senate and the House have committees that influence DoD and the budgets. The Senate Armed Services Committee is responsible for a wide variety of policy and budgetary issues. The House Armed Services Committee has a wide range of responsibility including research and development in support of defense systems. This major actor group also functions as individuals. Each member of Congress is elected, and, usually, each has the desire to be re-elected—a prime motivator. Therefore, members may vote for or against items depending on the impact it has on his/her constituent's opinion of the congressman—not on the impact of the nation as a whole. Alliances are formed among members of Congress to assist each others' agendas. Congress is influenced by and influences Security Threats, the DoD, the President, Industry, the U.S. Public, and the Military.

5. Institutional Sphere—Department of Defense

Although DoD is part of the Presidential Cabinet, it is considered a separate major actor group within the institutional sphere. The DoD basically has dual roles of responsibility: warfighting role and acquisition and logistics support role. It is DoD who procures and manages the major defense programs. Both the DoD and the military generate requirements for future military needs. All defense programs must be derived from documented and validated mission needs. For major defense programs, it is the Joint Chiefs of Staff who must approve the requirement for the program. However, Congress must give its approval for funding of the programs. Like Congress, DoD has much influence over acquisition policy. It is influenced by Congress, the President, the Military, Security Threats, and Industry.

6. Institutional Sphere—The Military

The military branches are not only the end users of the major defense systems, but they also play a key role in influencing the acquisition system. Each of the military departments is organized under the Secretary of Defense. They help with determining mission needs and generating requirements for major defense programs. The Military works closely with Industry, giving out funding for research of advanced technology and overseeing new or existing programs. The Military influences Industry, educating them on needs and requirements. On the other hand, Industry influences the Military suggesting new or different technology they believe would be better for the Military in an effort to shape the requirements. The Military anticipates and responds to Security Threats.

7. Institutional Sphere—The Executive Branch

The President is the Commander-in-Chief of the armed forces. However, it is Congress who has the power to declare war, determines the size of the military, creates policy that govern the military, and gives approval for funding major defense systems. The President submits a budget, which includes major defense programs, to Congress. After much discussion, Congress either approves with changes or disapproves. However, the President has the final voice of vetoing or signing these bills. The Executive Branch works closely with DoD, since DoD is part of the Presidential Cabinet. The President appoints the head of the DoD, the Secretary of Defense. As witnessed earlier this year in 2009, the Secretary of Defense has much influence over Congress, where Defense Secretary Gates warned Congress of spending money on unnecessary weapons. The President backed the Secretary of Defense saying he would veto any bill by Congress with funding for F-22s—an example of the interactions among these major actor groups within the institutional sphere.

8. Institutional Sphere—Industry

Industry plays a large role in the major defense acquisition system. It is industry that designs and produces the major defense weapons, employs hundreds of thousands of U.S. citizens to manufacture these weapons, and seeks to acquire more defense contracts for profit. Industry spends a portion of its own money in developing new technologies to shape the requirements of major defense systems. It lobbies to Congress in support of the systems they produce. Industry keeps abreast of Security Threats and designs solutions for DoD and the Military.

9. Institutional Sphere—The U.S. Public

The U.S. public plays a smaller role in the major defense acquisition system concerning day-to-day decisions on requirements, numbers, funding, etc. However, they still have influence on the system as a whole. One of the areas of influence is the many U.S. citizens who are employed as part of the defense-contracting arena or the civilian acquisition workforce. The employment not only helps them as individuals, but it also stimulates economic development in their region. Another area of influence is their right to vote. It is the U.S. public that chooses both the President and the congressmen. The U.S. public is influenced by Security Threats. Many citizens are actively involved in trying to influence their congressman and are concerned about either too much military presence in other nations, not enough military presence, anti-war, pro-war, etc. With the wars in Iraq and Afghanistan, many families have been affected by members serving or dying in these wars and all of the other social implications surrounding it. The U.S. public has a voice, and therefore influence, on the use of their tax dollars.

10. Institutional Sphere—Security Threats

Security threats have always played a key role in the major defense acquisition system. The Cold War is a great example of a threat that influenced the acquisition and production of multiple major defense systems. It is the goal of the U.S. to protect its interests. Thus, when security is threatened, the military is called on and equipped to fight the threat.

F. CLIOS ANALYSIS

Basically, there are four goals among the major actor group for acquiring major weapon systems: (1) national security through acquiring systems with the required capability; (2) economic growth as seen with employment, generation of technology, and foreign exchange earning thru imports; (3) economic stability by acquiring capable systems while keeping public expenditures within limits; and (4) continue to build or sustain relations with other nations (Kausal, 1999). Therefore, the question remains as follows: Is it possible to (a) buy weapon systems with (b) enhanced capabilities at an (c) inexpensive price for financial stability and within a budget during a (d) reasonable amount of time while (e) generating jobs and useful technology in both the defense and civil sectors, which still (f) sustains or strengthens relations with other nations?

Past answers to this question, and solutions to this complex problem, have involved compromise. Future answers most likely will continue to include compromise on one or more of the elements involved. However, with the insight gained through the CLIOS Process, a more holistic approach can be taken to identifying the real problems with the system and implementing solutions. Although only the Representation Stage has been applied to the major defense acquisition system, preliminary analysis can begin using the knowledge obtained of the subsystems in the physical domain and the major actor groups within the institutional sphere. Obviously, it is necessary to proceed through the iterative CLIOS process to understand, validate, refine, or modify. Nevertheless, with this current knowledge, two observable problems with corresponding solutions are presented.

1. Observation I: Long-term Decisions—Short-term Information

From the CLIOS analysis, one of the problems appears to be long-term decisions being made on short-term information. The problem illustrated in Figure 27 shows long-term system acquisition decisions made in an environment utilizing short-term information. The result is a tendency for the institutions below the dashed line to underestimate future costs.

The literature review conducted in Chapter II repeatedly revealed funding and production decisions being made on programs where realistic technology performance was unknown. Garvin and Roberto (2001) said, "facts come in two varieties: those that have been carefully tested and those that have been merely asserted or assumed” (p. 32). Due to the time period imposed, there is not enough time to carefully test.

In their research on why people or groups make decisions without the necessary knowledge, Cho, Jerrell, and Landay (2000) identified seven barriers to knowledge-based decisionmaking. The barriers identified apply to the weapons defense acquisition system: (1) Limited understanding of the total customer need; (2) Political/financial instability; (3) No time to share insights or solutions; (4) Culture Clash, (5) Process/cultural complexity; (6) Ineffective or nonexistent communication; and (7) Geographic dispersion of workers (p. 2–7). In order to have knowledge of a particular subject, a person undergoes a sequence of steps. In the beginning, data is gathered from dispersed elements. Once a pattern is seen in the data, then information is obtained. However, a person or group does not have knowledge until both the information plus experience come together. The current cycle for making decisions, does not allow enough time to make these important decisions based on real knowledge.

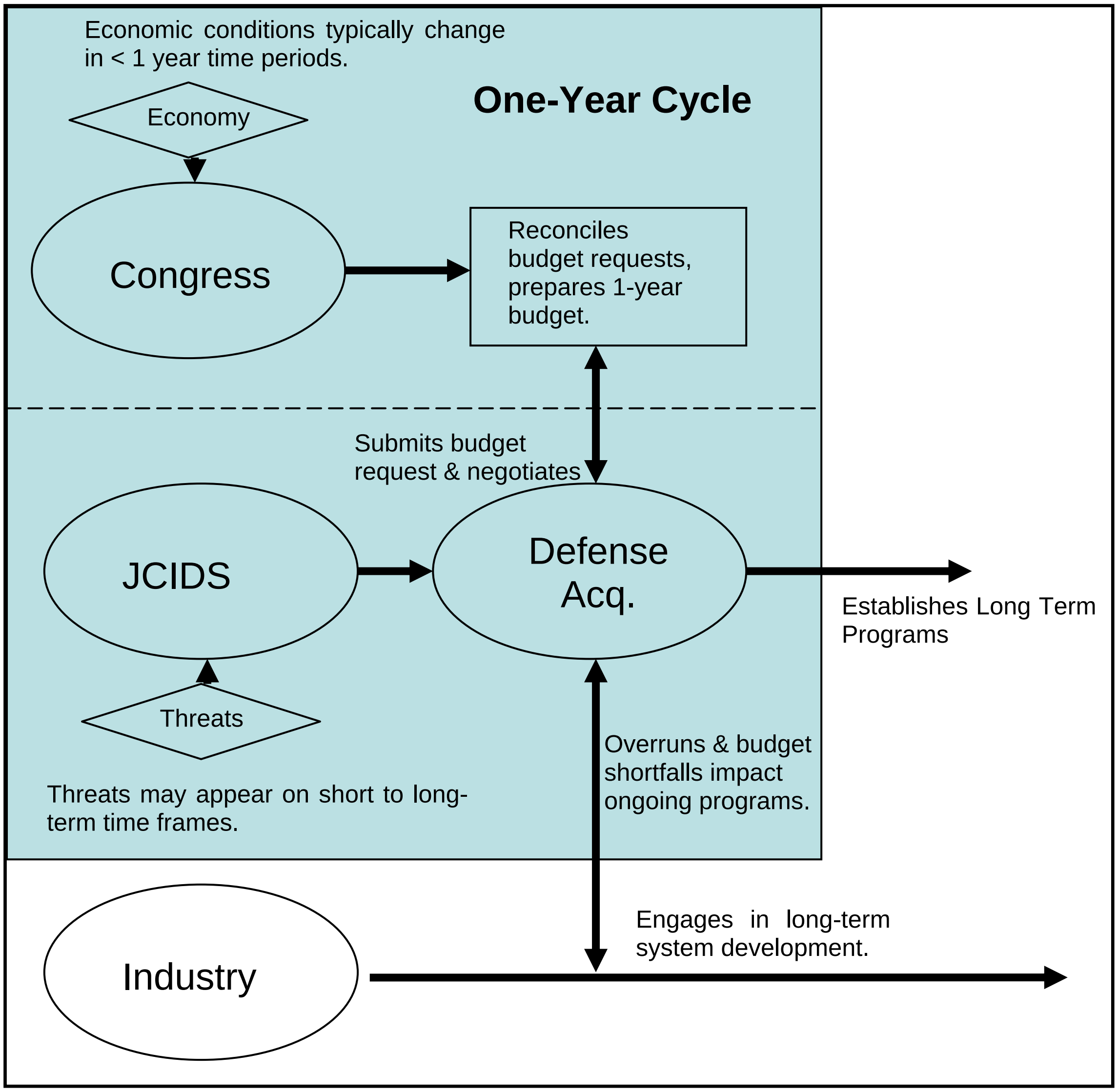


Figure 27. CLIOS Representation: Long-term Decisions – Short-term Information

2. Solution I: Integrated Process Team

A possible strategic alternative to the current operation is an Integrated Process Team. Congress, JCIDS and the Defense Acquisition System would form an integrated process team jointly considering both near and far-term economic conditions and security threats before new long-term defense programs were approved and funded. See Figure 28 for an illustrated depiction.

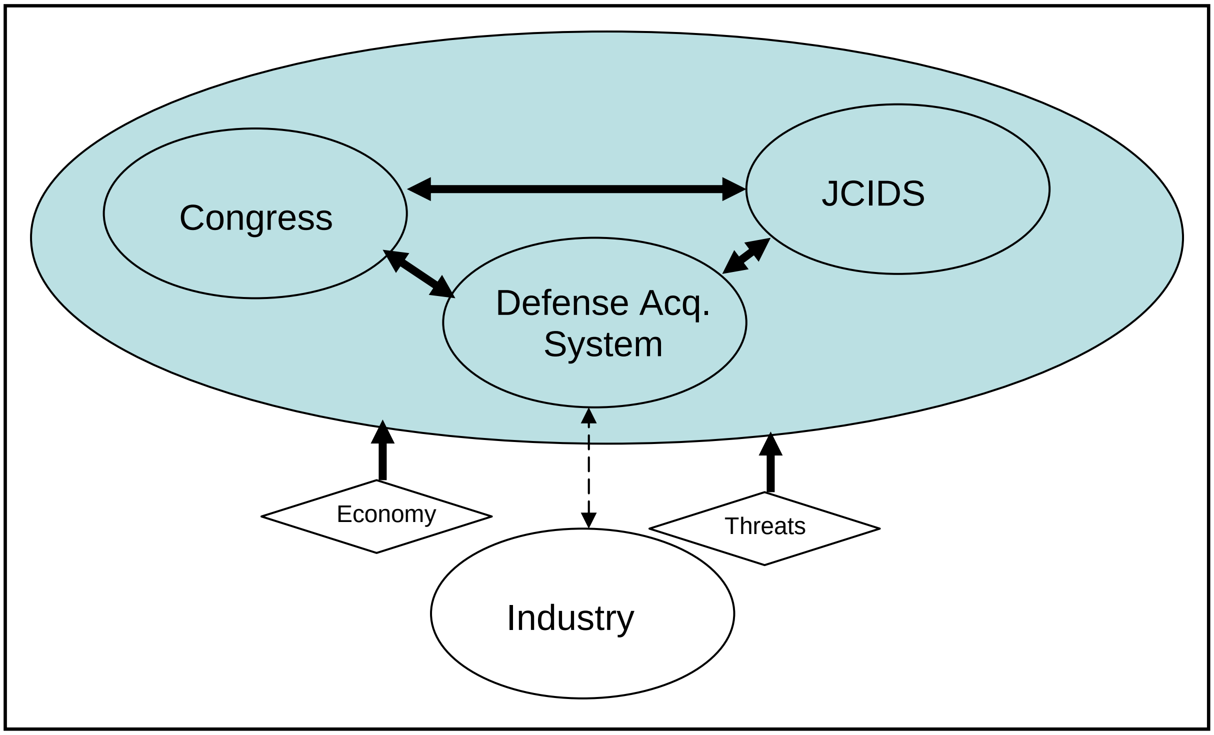


Figure 28. Integrated Process Team

Of course, there are barriers and challenges to an idea such as this, one being the challenge of implementing such a team. It is important to bring together the right people to work together as a team on this problem. The idea of an integrated team is not new. France has Integrated Program Teams that includes the individual services, DGA, which is the DoD equivalent, and industry. Germany has Integrated Project Teams, which bring together all stakeholders including industry except during competition. The UK has Integrated Project Teams where responsibility and accountability are combined to focus on the customer and achieve seamless flow of responsibility from concept to disposal. Like Germany, the UK involves all stakeholders including industry except during competition. The U.S. uses many Integrated Product Teams, each focusing on a different product.

3. Solution II: Mandated Systems Engineering Organization

Another possible strategic alternative is to have a new federally mandated systems engineering organization. This systems engineering organization would consider economic and threat conditions, analyze technological maturity, and make independent cost estimates as inputs to new defense system acquisition decisions. It would be equally accountable to Congress and DoD, not just a DoD office as the one stood up in early 2009. If the technology is immature, the federal systems engineering organization would determine requirements for technology development programs. Industry would be awarded contracts, not on the basis of lowest cost, but rather on the ability to meet the federal systems engineering requirements. This alternative does not require formation of an integrated team.

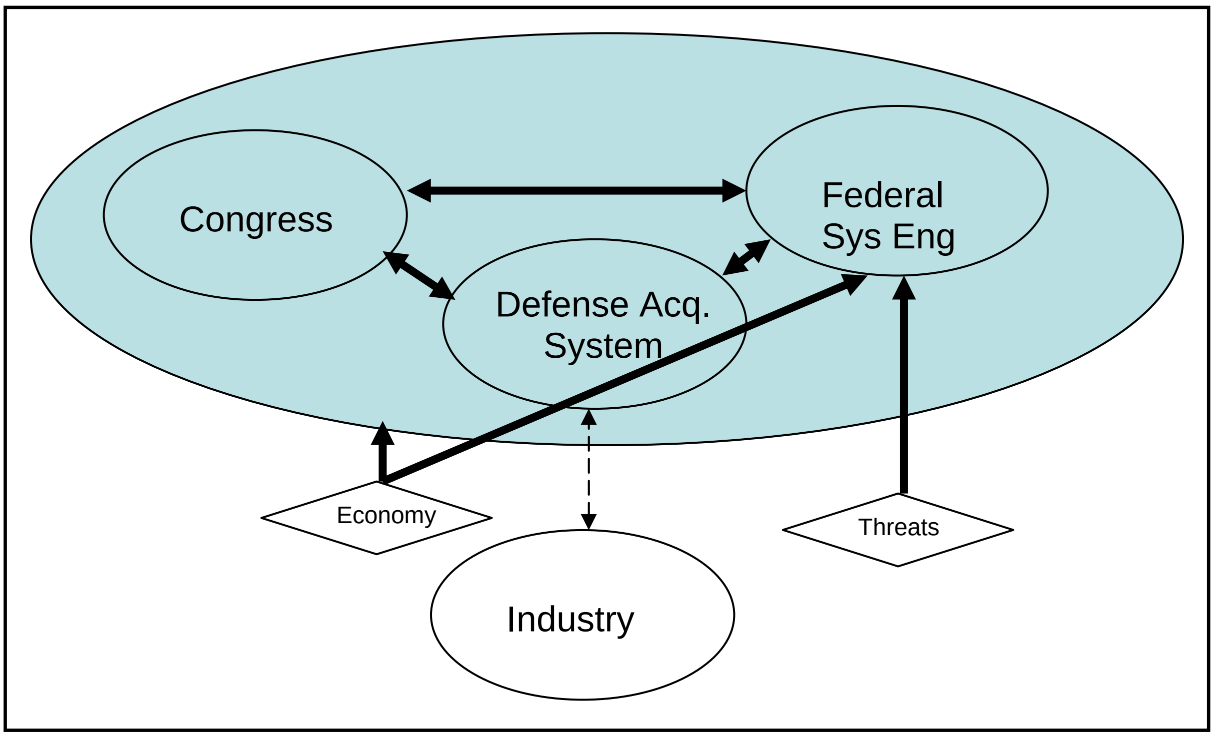


Figure 29. Mandated Federal Systems Engineering Organization

4. Observation II: Working in Silos—Little Accountability

Another observation is there are times when major actor groups make decisions or work in silos. Each of the major actor groups is not “evil.” They work independently for causes, which, essentially, are not incongruous. However, when programs break down, fingers are pointed and blame is assigned, while it is hard to determine what went wrong and where. These independent actions facilitate inconsistency throughout the life cycle of the program. This results in little accountability for the overall problems of the whole system. See Figure 30 for a depiction of this.

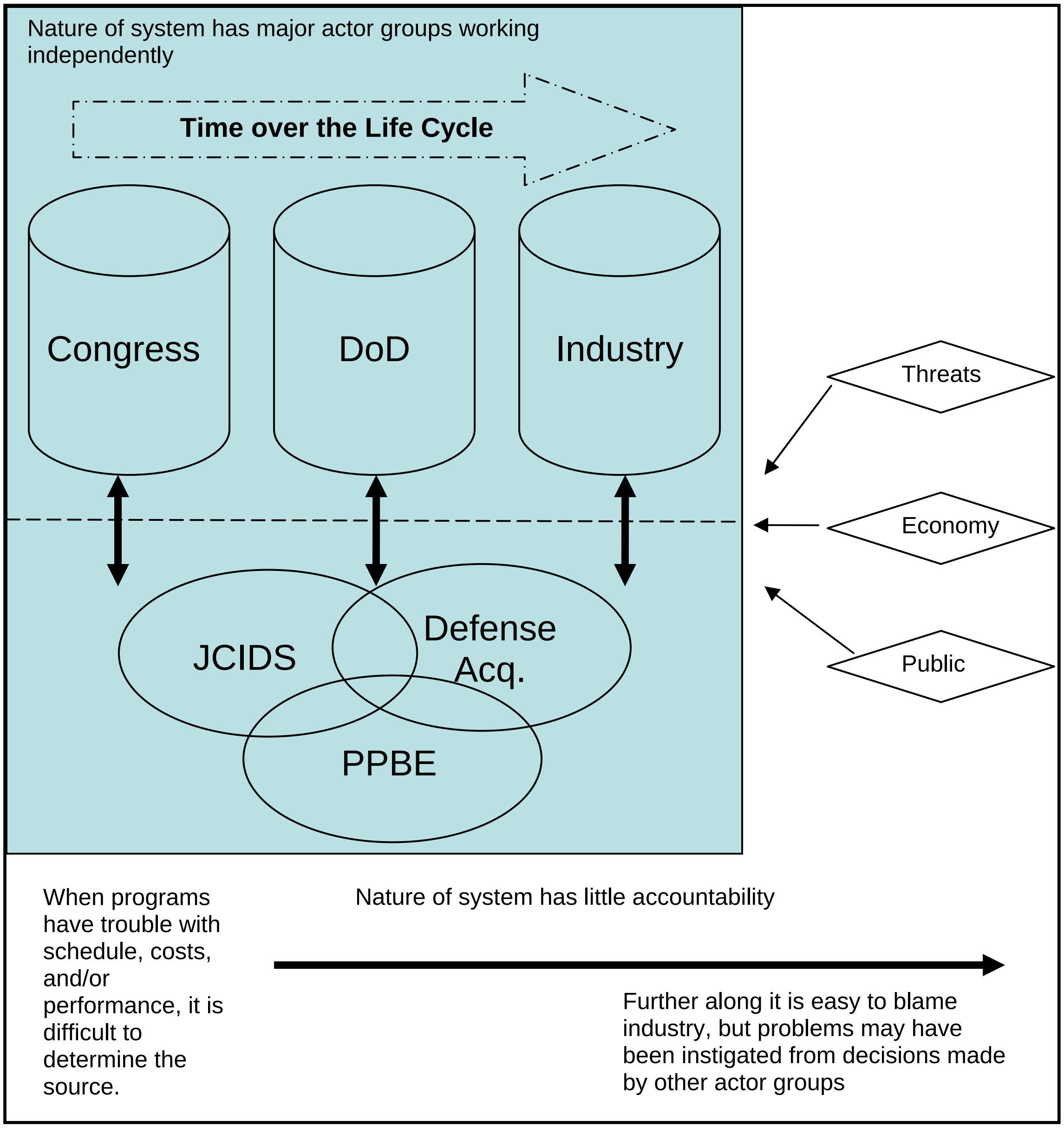


Figure 30. CLIOS Representation: Working in Silos – Little Accountability

5. Solution III: Defense Acquisition Accountability

This final possible strategic alternative is to have a hybrid of the Integrated Process Team and the Federal Systems Engineering organization. This hybrid would be a program-based congressional, DoD and industry coalition resulting in each partner economically penalized for large overruns, schedule slips, or other issues within a program. All will be held accountable by the independent, Federal Systems Engineering organization. See Figure 31.

Accountability would have to be instilled at every level in order for consistency and stability to thrive within the program. Changes will include concrete requirements, full commitment to funding, and minimized time from order to delivery.

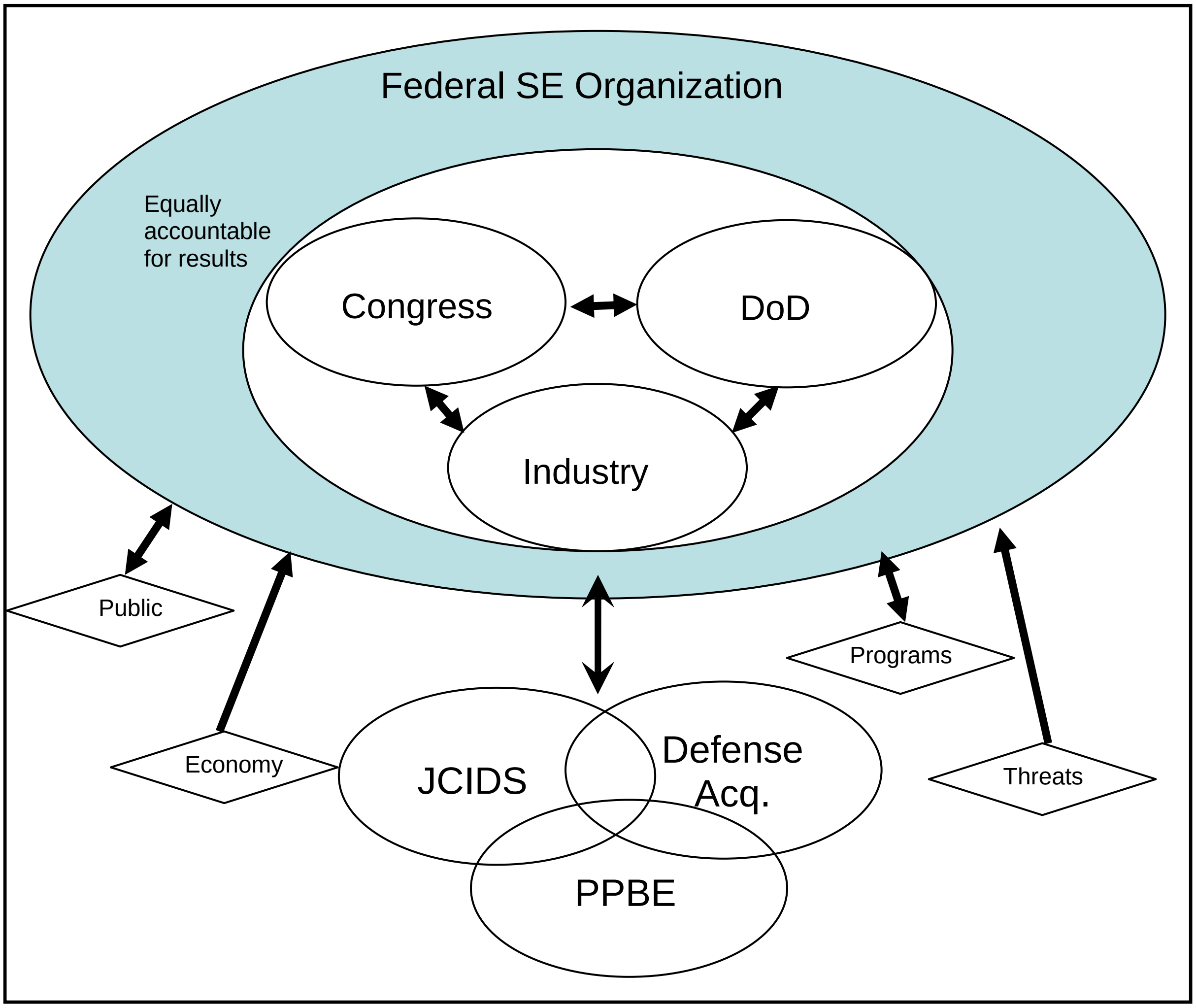


Figure 31. Defense Acquisition Accountability

G. CONCLUSION

The first stage of the CLIOS Process, the Representation Stage, was applied to the major defense acquisition system. Essentially, there are four steps within this stage. Each step was discussed concerning the major defense acquisition system. The outputs of this stage rendered a better understanding of the subsystems within the whole system as well as the major actor groups influencing the system. As this system continues to progress through the other stages of the CLIOS Process, the iterative nature of the process will require returning to the Representation Stage and modifying or refining as necessary.

Despite continuing with the CLIOS Process, initial analysis was conducted based on the observations of Stage 1. This resulted in two observations: (1) Long-term decisions made on short-term information and (2) Independent working leads to lesser accountability. Three strategic alternatives were identified: (1) form an Integrated Process Team with Congress, JCIDS and the Defense Acquisition System to jointly consider both near and far-term economic conditions and security threats before new long-term defense programs were approved and funded; (2) form a mandated Federal Systems Engineering organization equally accountable to both Congress and DoD to consider economic and threat conditions, analyze technological maturity, and make independent cost estimates as inputs to new defense system acquisition decisions; and (3) create a hybrid of the two previous solutions to implement accountability at all levels of the acquisition to all major actor groups. Of course, challenges to implementation will exist. However, as stated above, continuing with the CLIOS Process will facilitate in refining the strategic alternatives, as well as implementing them.

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V. CONCLUSION

A. CONCLUSION

Analyzing the major defense acquisition system is a challenging, complex process. The system has been plagued with problems since the beginning. Hundreds of reports were written on these issues and recommendations for improvement have been plentiful. Although social science research such as this usually concludes with direct recommendations for changing public policy, this research is limited to providing a better foundation for understanding the system. The goal of this research was to improve understanding of the intricacies of the U.S. major defense acquisition system for framing future solutions. The CLIOS Process provides such a framework for understanding a complex, large-scale, interconnected, open, sociotechnical system.

B. SUMMARY OF KEY POINTS

The system surrounding major weapons acquisitions continues to produce unwanted results: enormous cost overruns, unsatisfactory schedule delays, and decreased performance. The U.S. major defense acquisition system is very complex with many stakeholders, decision makers, and outside influences. The major defense acquisition system is not influenced by DoD and Congress only. It is subject to the President's approval, the requirements of the military, the capability of industry, the security threats from other groups or states, and the opinions of the American public.

Although policies are in place to thwart the progression of a program with unproven technology, Congress continues to approve budget for these programs with undemonstrated technology resulting in increased costs, schedule delays, and lesser performance than anticipated. Congress adds to the issues by not committing long-term to programs that do have proven technology. The funding is released incrementally without assurance for the future. Congress continues to add items to the DoD budget, which were never requested by DoD. Yet, it slashes other programs, which were requested based on identified mission needs and requirements. On the other hand, DoD continues to ask for weapons systems for wars that are no longer being fought, not recognizing the U.S. has a different enemy to fight with different capabilities needed to be successful.

Industry, along with other associated acquisition personnel, is continually blamed for insufficient management or mismanagement in general. There are very few prime contractors competing for very few major defense weapons acquisition programs. In order to keep contractors "alive" and to keep a sizeable and knowledgeable defense workforce, many contracts are split and shared between two or three.

C. LESSONS LEARNED / HEURISTICS

There are hundreds of quality, valuable reports available to better understand the system and influences. GAO continues to report on major defense acquisitions and continues to make recommendations. However, it appears that either no one takes heed, or policies are created but not implemented.

What is best for the nation is not always the agenda of the stakeholders. Congressmen continue to lobby for programs that are best for their region and constituents but not necessarily best for the current U.S. military needs. The military continue to ask for more than originally required or funded causing requirements creep. Industry shapes the military requirements based on their products.

The best technology has become the enemy of good enough technology. Advanced, unproven technology has been an issue with most major defense weapon system acquisitions. The U.S. is the dominant military in the world with the most advanced technology. The U.S. spends more than any other country. Some of the advanced technology being sought is not necessary to fight and win against the threats faced by the U.S. today.

Accountability must be injected in the acquisition culture. There are "too many hands in the pot" to know who is accountable for what. In terms of the CLIOS Process, there are too many major actor groups with influences on the system. Everyone involved in the acquisition process—Congress, DoD, the Military, Industry—must assume a sense of accountability to the U.S.

The discipline of systems engineering has already defined guidelines for program success: Requirements management and definition; Systems architecture development; System, subsystem design; Systems integration and design; Validation and verification; System development and post deployment; etc. These concepts should be practiced by all stakeholders, and major actor groups, within the major defense acquisition system. Although DoDD 5000.02 mandates systems engineering on programs, it seems to apply to the industry contractors. Systems' thinking is not prominent in all aspects of the system. Everyone involved in decision making concerning major defense acquisition must understand systems engineering and must employ a systems thinking approach.

The CLIOS Process unveils the complexity of the system. Utilizing the CLIOS framework emphasizes the complexity of the U.S. major defense acquisition system even more. The Representation Stage is just the beginning of wading through the subsystems and actor groups. Although applying the entire CLIOS Process to the U.S. major defense acquisition system will take time, it will uncover more points of leverage for improvement and allow for real changes to be implemented.

D. RECOMMENDATIONS AND FURTHER RESEARCH

Further research should be conducted on the U.S. major defense acquisition system using the CLIOS Process. The remaining stages of the CLIOS Process, especially the iterative aspects of the process, should be applied to the U.S. major defense acquisition system. Much more will be discovered about the system, its behavior, and the leverage points for strategic alternatives. As the application of the CLIOS Process continues, deeper understanding of the system will be obtained. Stage 1 allowed for the initial understanding of the system, as well as provided the initial mental mapping of links within the physical and institutional systems. This stage produced general insights into the U.S. defense acquisition system. However moving into Stage 2, the analyst will gain a detailed and quantitative understanding of the system. Stage 2 will provide greater understanding and appreciation for system possibilities, limits, uncertainties, and sensitivities. Because of the newer comprehension during Stage 2, the analyst will go back to Stage 1 and modify and refine the initial structure—an iterative process. Finally, implementing strategic alternatives in Stage 3 will cause changes within the physical domain and the institutional sphere surrounding the major defense acquisition system. These changes must be evaluated, monitored, and adapted, as needed for improvement to the system as a whole.

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