AN EVALUATION OF DEFENSE CONTRACTING
BASED ON TRANSACTION COST THEORY

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(ABSTRACT)

This study investigates the use of the transaction cost paradigm, as a framework, for evaluating defense contracts and exploring problems related to defense contracting. The study shows that defense contracting is beleaguered with bounded rationality and uncertainty problems, and furthermore, that bounded rationality and uncertainty can lead to opportunistic behavior within defense contracting. The study shows, in particular that adverse selection, moral hazard, and hold-up problems exist within defense contracting.

Based on the results of this study the transaction cost paradigm can be used as a framework for evaluating defense contracts and related problems. The results also indicate that hold-up problems and moral hazard problems may be minimized by using proper contracts or acquisition strategies. Based on the case study in Chapter III there does not appear to be a contractual solution to adverse selection problems.
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Chapter I

Introduction

The Department Of Defense (DOD) has been criticized for the types of contracts used to acquire weapon systems and the types of acquisition strategies used to procure those systems. This thesis will investigate the use of the transaction cost paradigm, as a frame work, to explain why DOD has chosen specific contract types and acquisition strategies. Before the transaction cost paradigm is applied, however, it will be helpful to outline the approach and discuss its background.

Ronald H. Coase's article, "The Nature Of The Firm", has played a significant role in the study of transaction cost.\(^1\) Coase recognized that there was a cost associated with using the price system, and referred to this cost as a transaction cost. As Oliver E. Williamson writes "transaction cost are the economic equivalent of friction in physical systems"\(^2\). Transaction costs can be broken-down into ex ante and ex post components. The

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ex ante component is the cost of setting up a contractual relationship while the ex post component is the cost associated with contract execution. Transaction cost economics, then, can be viewed as the study of contracts and how they can be used to explain economic organization. According to Williamson, "Transaction Cost Economics adopts a comparative contractual approach to the study of economic organization in which the transaction is made the basic unit of analysis and the details of governance structure and human actors are brought under review". Moreover, as Williamson explains, the differences between transaction cost economics and other economic models of economic organization is that transaction cost economics

"(1) is more microanalytic, (2) is more self conscious about its behavioral assumptions, (3) introduces and develops the economic importance of assets specificity, (4) relies more on comparative institutional analysis, (5) regards the business firm as a governance structure rather than a production function, and (6) places greater weight on the ex post institutions of contracts, with special emphasis on private ordering (as compared with court ordering)".  

The key behavioral assumptions that Williamson addresses are bounded rationality and opportunism. These

assumptions are the topic of Chapter II. In Chapter III, the results of Chapter II are used to evaluate different types of DOD contracts. Chapter IV addresses asset specificity, while Chapter V uses the concept of asset specificity to evaluate DOD acquisition strategies. Chapter VI combines the analysis of contract types with the analysis of acquisition strategies.
Chapter II

The Key Behavioral Assumptions of the Transaction Cost Paradigm

Transaction cost economics is based on two key behavioral assumptions which are bounded rationality and opportunism. The purpose of this chapter is to demonstrate that defense contracting is plagued with bounded rationality and extreme uncertainty, and furthermore, that bounded rationality and uncertainty, within defense contracting lead to opportunistic behavior. Section II.1 focuses on the bounded rationality and uncertainty issues related to defense contracting. Section II.2 focuses on the opportunistic behavior associated with defense contracting.

Section II.1
Bounded Rationality

Bounded rationality is one of three forms of rationality that have been studied in the economic literature.\(^5\) Maximizing rationality is the strongest

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\(^5\) The three forms of rationality are maximizing rationality, bounded rationality, and organic rationality. Organic rationality will not be discussed in this thesis; however for those interested see Williamson, Oliver E.,
form of rationality and is tied to the Neoclassical approach to economic organization. An example can be found in any microeconomic text book where firms' input decisions are viewed as resulting from the minimizing action of cost subject to a known production functions and peoples' choice decisions are viewed as resulting from the maximizing of a utility function subject to known prices and income. This type of analysis assumes that firms and people make optimal decisions with the information necessary to make these decisions being obtained and analyzed for no cost.

Both firms and people are assumed to have perfect information. Therefore, by assuming maximizing rationality the study of contracts becomes trivial since complete contingent claim contracts can be written which would cover all contingencies and any opportunistic behavior. A complete contingent claim contract is designed so that all terms of the contract are specified and how the terms would change based on uncertain future events. In other words, no ex post situation or contingency would arise that could be disputed based on a claim related to the contract. Any possible ex post contractual problems that might arise would be handled in the ex ante phase through contract

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design. Therefore, only the ex ante component of the transaction cost would be relevant. Unfortunately, we do not live in a world were information is free and can be processed at no cost. Parties do not enter into a contractual agreement with perfect information.

This fact brings us to the second form of rationality. Bounded rationality is a moderate form of rationality which assumes that economic actors are "intendedly rational, but only limitedly so."6 This definition of rationality does not presume that economic actors act irrationally, but that their judgement is limited by the available information. The major difference between bounded rationality and maximizing rationality is that bounded rationality relaxes the assumption that information can be collected and analyzed at no cost. As a result, complete contingent claim contracts are not feasible, because the cost associated with collecting the necessary information and processing it would excessive.7 The study of imperfect information and the

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7. To help understand the complexity of a complete contingent claim contract imagine trying to write such a contract for renting a house. In the contract you would not only have to specify the length of the contract and the cost of renting the house but every possible contingency and an associated payoff for each contingency. As an example, a clause would have to be written in case the
cost of information has become increasingly popular within the economic literature. Most of the literature dealing with imperfect information has focused on insurance markets, but the analysis and conclusions can be applied more generally to the study of contracts. The insurance literature divides information into two types -- market information and event information. Market information is the ability to determine supply and demand offers of economic actors. Since DOD is the only weapon system buyer market, information is determined by the requirements for the weapon system and fiscal constraints. The other type of information is event information, which is the ability to determine exogenous events that effect the supply and demand offers of economic actors. Event information within DOD comes from changing world events which dictate the threat requirements for weapon systems and the demand for

7 cont. house was damaged based on acts of nature along with clauses dealing with the renters behavior. (i.e. if he can smoke in the house, play loud music, and how he must maintain the house. The list can go on virtually forever.)


weapon systems. Many sources of information uncertainty that exist within DOD have been humorously summarized in Schemmer's Theorem.10

SCHEMMER'S THEOREM

"When faced with a twenty-year threat, government responds with:
- a fifteen-year program
- in the Five-Year Defense Plan
- managed by three-year personal
- funded with single-year appropriations."

Underlining Schemmer's Theorem are three areas of information that are necessary when contracts are being designed -- technological, programmatic, and funding information.

Technological information is information associated with the materials and process that will be available once the weapon system is developed and ready for production. Weapon systems, such as new aircraft, helicopter or tactical missiles will take between five to ten years to develop. Because of the long development times DOD tries to predict what level of technology will be producible and affordable early in the weapon system program.11 Also,  

10. Schemmer's Theorem was taken from the Department of Defense Acquisition Improvement Program course, January 18, 1982.  
11. See Appendix A for information on the different stages of a weapon system program.
because of the long development time DOD must predict what the threat will be when the weapon system is ready to be produced. Failure to predict the threat could cause a weapon system to be developed for a threat that no longer exists or a weapon system that can be defeated by the threat when it becomes operational. Some of the technologies that are relevant to weapon systems development are electronics, engine, and types of materials which can be used to build weapon systems. Technology information uncertainty effects the design of the contract and will be discussed in Chapter III.

Programmatic information is schedule information which relates to the time line of a weapon system program and the quantities that will be purchased. To see the degree of programmatic uncertainty look at the information on page ten which shows quantity and schedule changes for forty-five DOD weapon system programs. The changes shown on page ten are based on schedules that were planned as the programs entered milestone II. The reasons for the changes vary in each case but the key issue is the information entering milestone II is not perfect and does

12. One of the arguments for cancelling the Air Force's B-2 bomber program is that there is no longer a need for a manned deep strike capability into USSR.
13. The definition of Milestone I and Milestone II are given in Appendix A.
Changes in Weapon System Quantities and Schedules\(^\text{14}\)

Quantity changes
- 22 Increases
- 16 Decreases
- 7 Unchanged

Schedule changes
- 39 Changed
- 6 Remained on schedule

not represent the actual program.

Funding information uncertainty is related to the way DOD is appropriated funds. Since DOD is appropriated the money to buy weapon systems from Congress it does not have direct control of the funding which effects the length of time in which contracts can be designed.\(^\text{15}\)

The examples of information uncertainty stated above depicts the lack of information that exists when designing DOD contracts. Because of the information uncertainty, bounded rationality is a reasonable assumption and the effects of bounded rationality must be considered when

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\(^{14}\) The data on the changes in weapon system quantities and schedules was taken from the Department of Defense Acquisition Improvement Program course, January 18, 1982. The information was based on the September 30, 1981 Selected Acquisition Reports, which are yearly publications required for major weapon system programs.

\(^{15}\) The Planning, Programming, and Budgeting process that all services must go through to receive funding is given in Appendix B.
evaluating defense contracts.

Section II.2
Opportunistic Behavior

Besides bounded rationality, opportunism must exist to create non trivial ex post contractual problems. If opportunism is not prevalent than contracts would simply be rewritten once the shortcomings that exist due to bounded rationality were observed. The rest of this chapter will be spent defining opportunism and show how it could apply to DOD.

Opportunism like bounded rationality is a behavioral assumption essential to the transaction cost paradigm. Opportunism is the strongest form of self-interest seeking behavior noted in the economic literature.\textsuperscript{16} Opportunism is defined to be a condition of self-interest seeking that contemplates guile. Opportunism's impact on contract design is closely tied to bounded rationality because economic actors involved in a contractual relationship will use asymmetric information prevalent when bounded

\textsuperscript{16} Self-interest seeking behavior has three forms. Opportunism is the strongest form followed by simple self-interest seeking which assumes that economic actors only have ex ante opportunistic behavior. The weakest form is obedience which is stewardship like behavior.
rationality exist to exploit the terms of a contract. One form of opportunistic behavior within contracts is the acquisition of information and then using it to better ones position based on the terms of the contract. An example of this form of behavior within DOD is the Navy's "Ill Winds" scandal. The "Ill Winds" scandal uncovered a series of illegal activities by contractors to obtain information that would better their position to win a contract. The focus of this example is not to show that opportunistic behavior is necessarily illegal, but that asymmetric information is used within DOD to better ones contract position.

Another form of opportunistic behavior that could be found within defense contracting is the withholding of information by the weapon system manufacturers. Weapon system manufacturers could withhold assessments of technical problems that may require changes to their designs. The information would not be uncovered until the contractor starts delaying the schedule and cost overruns are noticed. Once cost overruns are noticed it is usually too late and the program must be restructured which leads to more schedule delays and further cost overruns.

The P-7 is a maritime patrol aircraft that was
scheduled to replace the P-3C. Entering Milestone II Lockheed claimed that the P-7 would have up to forty percent commonality with the P-3C. Almost two years after contract award Lockheed claims that the design would not meet Navy requirements and had to redesign the aircraft. The redesigned aircraft is estimated to be less that five percent common with the P-3C. The redesign effort resulted in schedule delays and cost overruns of up to $300 million.17

Another example of potential opportunistic behavior on the part of defense manufacturers is the A-12 aircraft program. The A-12 is an attack aircraft scheduled to replace the A-6 aircraft. The A-12 is currently being built by the team of General Dynamics and McDonnle Douglas. After approximately three years General Dynamics has announced that they are having problems building certain sections of the aircraft. The problem have caused delays in the program and Navy officials expect the program to have cost overruns.18

17. For more information pertaining to the P-7 program see Smith, Bruce A., "Navy Cancels Lockheed's Contract to Develop P-7A", Aviation Week and Space Technology, July 30, 1990, p 16-19.

18. For more information pertaining to the A-12 program see Almond, Peter, "$52 Billion Navy Plane Program Falters; Suspicions Arise on Hill", Washington Times.
It is hard to determine if the problems associated with the P-7 and A-12 programs are caused by opportunistic behavior or are caused by unforeseen technical difficulties at the time of contract award. If the latter is the case then the problems were caused by the existence of bounded rationality.

The intent of this chapter is to define the key behavioral assumptions underlining transaction cost theory and to show that these assumptions describe the types of behavior found in defense contracting. The next chapter focuses on the contracting problems that occur as a result of these behavioral assumptions.
Chapter III

Adverse Selection, Moral Hazard and Agency Cost
In Defense Contracting

In this chapter the roles of the "economic actors" are discussed along with the contractual problems encountered by the actors due to bounded rationality and opportunistic behavior. The chapter focuses on two informational conditions which create contractual problems and agency costs. They are -- adverse selection and moral hazard. At the end of this chapter are two case studies that highlight the problems of adverse selection and moral hazard.

The contractual relationship between DOD and weapon system manufacturers can be characterized as an agent-principal relationship where both behave in an opportunistic manner and must agree on contract terms even though they each possess asymmetric information. An excellent description of the agent-principal relationship is given by Pratt and Zeckhauser.

"First, given information asymmetries - agents typically know more about their tasks than their principals do, though principals may know more about what they want accomplished - we cannot expect any business enterprise or business institution to function as well as it would if all information were
costlessly shared or if the incentives of principal and agent(s) could be costlessly aligned. This shortfall is sometimes called the agency loss or costs.\textsuperscript{19}

In defense contracting, DOD is the principal and the weapon system manufacturer is the agent.

There are two informational conditions which create both contractual problems and agency costs. These conditions are adverse selection and moral hazard.\textsuperscript{20}

Mark Pauly describes adverse selection and moral hazard as follows:

"two cases in which the absence of information could interfere with the operation of insurance markets, or indeed, of any market in risk. One is the case of "adverse selection", in which the insurer cannot determine some characteristics of the insured that are relevant to the determination of the probability of the future state of nature. Because the insured is assumed to know these characteristics, Arrow has called this a case of unequal distribution of information. The other case is similar in that the insurer is assumed not to know or to be able to monitor the present (purchase-date) state of nature, but differs in that the insured also has the power and incentive to change this unobservable state in


response to insurance coverage. This is one kind of problem of moral hazard.\textsuperscript{21}

Pauly's description of adverse selection and moral hazard centers around the issue of asymmetric information. Adverse selection problems exist because agents and principals agree on contract terms based on the asymmetric information they each possess. Moral hazard problems exist because of problems monitoring the contract once it is being executed.

Adverse selection problems can be overcome by collecting and analyzing the information relative to the contract before the contract is executed, but the cost can be prohibitive and the information may not be accurate. Moral hazard problems can be overcome by monitoring the performance of the contract once it is executed, but the monitoring costs can also be prohibitive.

Another alternative to expensive information collection, analysis, and monitoring could be a properly designed contract. A contract that properly aligns the incentives of the agent and principal may eliminate many of

the problems associated with adverse selection and moral hazard and reduce agency costs.

The Pareto optimal contract for handling adverse selection and moral hazard problems is a complete contingent claims contract, since complete contingent claims contracts by definition resolve all relevant contract issues before the contract is signed. Unfortunately the information that is needed for contingent claims contracts makes them impossible to write and negotiate. The second best contracting solution would be an incomplete contract. Incomplete contracts do not contain all possible contingencies, they due, however, allow for renegotiation when problems appear that were not foreseen when the contract was negotiated. Although incomplete contracts do not need all of the information that complete contingent claims contract need, they do increase the potential for adverse selection and moral hazard problems. The rest of this chapter describes the key issues associated with designing incomplete contracts for DOD.

Weapon systems manufacturers are awarded contracts based on their responses to a request for proposal
(RFP). The RFP evaluates the responses based on three criteria: technical qualities, cost and management. If any of the offerors fails to thoroughly investigate the problems associated with their weapon system designs in any of the three areas then, this could lead to the selection of the wrong weapon system manufacturer. It is important to note that if the contract is not structured properly there is an incentive to be overly optimistic when responding to the RFP because weapon system contracts can insure both work and profits for a relatively long period of time. Often if the inaccuracies are not picked up before contract award they will go unnoticed until years into the contract when cost overruns and schedule delays become apparent. Once cost overruns are revealed there are three options DOD can take 1) terminate the contract and find another way to meet the requirements (i.e. recomputed the weapon system, upgrade an existing weapon system), 2) renegotiate the contract to incorporate the cost overruns and schedule slips, or 3) force the contractor to fix the problems using corporate funds.

The critical issues facing DOD when choosing an

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22. The RFP is used by the contracting service within DOD to collect and evaluate information associated with the manufacturers design and lowers the probability of adverse selection problems. For more information about the
option are time (how long will it take to get the weapon system operational) and money (how much will it cost to fix the problem). DOD has used all the options stated above to solve potential adverse selection problems. For example, on the P-7 program the Navy choose option one, and the Air Force choose option two on the B-1 bomber program.23

Adverse selection could be minimized by using a firm fixed price (FFP) contract. FFP contracts are designed to shift all the risk associated with the program onto the weapon system manufacturer, creating an incentive for the manufacturer to give realistic weapon system designs and costs. Although, FFP contracts seem to be the solution to adverse selection problems they do have drawbacks.

FFP contracts do not prevent court action. If the contractor is faced with a large cost overrun they may go to court and try to force the government to pay for some or all of the additional costs on the grounds that some DOD action caused the cost overrun.24 Also, FFP contracts do

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23. See Smith, Bruce A. p. 16-19 for details on the Navy termination of the P-7 contract and see Kitfield, James, "The price of concurrence", Military Logistic Form, May 1987, p. 18-25 for details on the B-1 contract renegotiations.
24. The P-7 contract has recently been terminated by
not protect against the contractor claiming bankruptcy. Court action and bankruptcy result in DOD not receiving the weapon system in the required time frame which can result in additional cost to DOD. The additional costs include legal costs, finding and qualifying another manufacturer, and modifying another weapon system until the original weapon system becomes operational. These additional cost in the form of time and money often cause DOD to renegotiate the contract.

Besides the legal ramifications involved with FFP contracts there is also additional cost due to the shifting of program risk onto the manufacturer. Since FFP contracts require the weapon system manufacturer to absorb all of the program risk, he will charge the government a risk premium. The risk premium is the manufacturer's cost for insuring DOD against cost overruns. The risk premium is a cost inefficiency to DOD because DOD can insure itself for virtually no cost through risk pooling.

Risk pooling is based on the Law of large numbers. Each weapon system program has an expected

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24 cont. the Navy and Lockheed is appealing the termination. For details see Smith, Bruce A., "Navy Cancels Lockheed's contract to Develop P-7A", Aviation Week and Space Technology, July 30, 1990, p. 16-19

25. The Law of Large numbers states that the
cost $E(C)$. Associated with $E(C)$ is a variance $\text{VAR}(E(C))$ that is based on the uncertainty related to the specific program. $\text{VAR}(E(C))$ is a measure of the risk associated with the program costs being greater than $E(C)$. To insure against $\text{VAR}(E(C))$ DOD could buy an insurance policy. The cost of the insurance policy would be a function of the probability that the program costs are greater than $E(C)$. In accordance with the Law of large numbers if DOD pools a sufficiently large number of programs it can reduce $\text{VAR}(E(C))$ to virtually zero.\(^{26}\) Therefore, DOD could insure itself for virtually no cost by pooling risk. DOD is in a very good position to pool risks, since it administers more contracts than any other government agency and much more than any weapon system manufacturer. Risk pooling is widely used by insurance companies to insure against negative profits. Within financial markets risk pooling is a called diversification. Using risk pooling

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\(^{25}\) cont. probability that the average of an independently observed random variable from the same distribution will differ from the mean by less than an arbitrarily prescribed error tends to one. Soong, T. T., Probabilistic Modeling and Analysis in science and Engineering, New York: John Wiley and Sons, Inc., 1981, p. 92.

\(^{26}\) Based on the Law of Large numbers, as the number of independent programs are pooled from the same distribution their $\text{VAR}(E(C))$ will tend to zero as the number of programs added to the pool tends to infinite. For additional information on risk pooling see: Layard and Walters, Uncertainty, *MicroEconomic Theory*, New York, N.Y.: McGraw and Hill, 1978, p. 362-364.
DOD can behave as if it is risk neutral with respect to cost overruns and would be best served bearing all the program risk, since they could insure themselves for near zero costs.

A cost plus fixed fee (CPFF) contract is the contract type used to optimize risk pooling and is commonly used in defense contracting. A CPFF contract is the opposite of an FFP contract. Unfortunately, CPFF contracts do not have proper incentives to control opportunistic behavior on the part of the manufacturer. The contractor has no incentive to control cost beyond those specified in the contract; therefore, the manufacturer has an incentive to impose cost above the marginal cost to manufacture the system.\footnote{The manufacturer will increase manpower above the optimal amount (realize diminishing returns with respect to labor) to reduce plant layoffs. The manufacturer is able to do this because DOD can not afford the monitoring cost needed to observe this type of behavior. Recently Emerson electronic co. pleaded guilty to providing false and inflated cost estimates for electronics equipment sold to DOD between 1983 and 1987, \textit{Aviation Week and Space Technology}, May 7, 1990, p. 40.} The conflict between proper incentives and efficient risk sharing related to CPFF contracts result in what Pauly calls moral hazard. The moral hazard problem forces DOD to a class of contract types known as incentive contracts. Incentive contracts are an attempt by DOD to provide incentives to the manufacturers to minimize
opportunistic behavior (moral hazard) by rewarding them with higher profits and minimizing the risk premium the government must pay. An example of an incentive contract used by DOD is the Fixed Price Incentive (FPI) contract. FPI contracts involve the negotiation of a target cost and fee, a ceiling price, and a sharing arrangement between the manufacturer and DOD. The target cost is the negotiated value of the contract. The ceiling price is the most DOD will pay for the weapon system. The sharing arrangement is a cost split between DOD and the manufacturer for cost greater than or less than the target cost. The graph of cost vs. Fee for a FPI contract is shown in Figure 1. An example of the share arrangement would be seventy - thirty, where DOD will pay seventy percent of the cost above the target cost and the manufacturer will pay thirty percent. The share arrangement is closely tied to the amount of risk in the contract (the degree of uncertainty that exists). If the risk is high DOD will take the larger share percentage. This is consistent with efficient risk sharing.

28. DOD uses other forms of incentive contracts. Such as cost plus incentive fee and cost plus award fee. Typically cost plus contracts are used on weapon system programs that have high degrees of technical uncertainty. For additional information about incentive contracts see: The contracting for Cost Analysts, Assistant Secretary of the Navy Shipbuilding and Logistics, 1988.

29. Price is equal to cost plus fee.
FIXED-PRICE INCENTIVE PROFIT MATRIX

TARGET COST = 100
TARGET PROFIT = 10
CEILING PRICE = 120

figure 1
In this chapter the contracting difficulties associated with adverse selection and moral hazard were discussed. The conclusions drawn from the analysis showed that FFP contracts could minimize the problems associated with adverse selection, by shifting the program risk onto the manufacturer. There are drawbacks to FFP contracts, however, FFP contracts can cause additional costs because the weapon system manufacturer will charge DOD a risk premium. The risk premium is a cost that DOD would not have to pay if it pooled risk. The contract type that maximizes the benefits of efficient risk pooling is a CPFF contract. The analysis of CPFF contracts showed that CPFF contracts lack proper incentives to control opportunistic behavior of the moral hazard type. A contract designed to minimize opportunistic behavior and still take advantage of risk pooling is an incentive contract. The following two case studies highlight adverse selection and moral hazard problems within defense contracting. The next chapter discusses the concept of asset specificity and demonstrates how the concept applies to defense contracting.
Section III.1
The P-7 a Case of Adverse Selection
Within the Navy

The P-7 aircraft program was a competitive full scale engineering development (FSED) contract. The companies involved in the competition were: Lockheed Corporation, McDonnell Douglas Corporation, and Boeing Company. In 1988 the Navy awarded Lockheed a FFP development contract for the P-7. The P-7 aircraft was meant to replace Lockheed's P-3C aircraft in the mid 1990's, as the Navy's long range patrol aircraft. Some critical Navy requirements put on the design were that the P-7 be able to loiter for up to four hours at a distance of 1,600 miles from base. During the competition Lockheed provided the Navy with information, in the RFP, that stated that the design would meet the Navy range and endurance requirements, and be forty percent common with the P-3C. Over a year into the contract Lockheed claims that the aircraft design submitted in the RFP could not meet the

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Navy requirements and that in order to meet the requirements they would have to redesign the aircraft. The redesigned aircraft is predicted to be less than five percent common with the P-3C. After discovering that the design submitted in the RFP would not meet requirements the Navy has terminated the Lockheed contract on grounds of default. Lockheed is appealing the termination by default charges and is seeking termination "for the convenience of the government". Lockheed chairman Daniel Tellep maintains that the errors found in the original design could not be uncovered until the work done to date was completed.

Mr. Tellep's convection highlights the adverse selection problem. Based on Mr. Tellep's statement the Navy did not have enough information to determine the future state of the Lockheed design during the competition. Therefore, the P-7 contract was awarded under the condition of adverse selection. Another interesting point brought out in this example, is that shifting the program risk onto Lockheed, through the use of a FFP contract, did not prevent the adverse selection problem. Since the FFP contract did not prevent adverse selection than two possible conclusion are: 1) The benefits of potential long term work and profits that the P-7 contract offered Lockheed out weighed the potential risk associated
with the FFP contract. 2) The potential for a favorable court decision for Lockheed out weighed the potential risk associated with the FFP contract. In either case, the case study seems to indicate that adverse selection problems and the associated agency costs can not be reduced solely based on contract design.
Section III.2
The Phoenix Missile a Case of
Moral Hazard\textsuperscript{31}

The Phoenix missile is a supersonic, all-weather, long range air-to-air missile built by Hughes Aircraft Company, for the Navy. The Phoenix missile, designated the AIM-54A, has been in production since 1971.

In 1980 the AIM-54A was upgraded to increase the missile's effectiveness against enemy targets. The upgraded AIM-54A was designated the AIM-54C. The 1980 contract for the AIM-54C was a FFP contract for sixty missiles. In June of 1980 a Production Readiness Review (PRR) was conducted. PRR are performed to insure that the manufacturer is qualified to build the weapon system. The results of the PRR determined that Hughes was capable to build the AIM-54C. In February of 1981 a Production Assessment Review (PAR) was conducted. During the PAR the weapon system is inspected to insure that it is built to the proper specifications. The results indicated that Hughes was building AIM-54Cs to specifications. After

\textsuperscript{31} Information used for the case study came from the following sources: Biddle, Wayne, "Pushing for Weapons That Work", The New York Times, July 8, 1984; Kitfield, James, "Unguided Missiles?", Military Logistics Forum, April 1988, P. 18; LSA for the Naval Air Systems Command, Phoenix AIM-54C Missile Production Costs, May 24, 1989
alleged AIM-54C misfires a special team of Navy officials were sent to the Hughes production facility to inspect AIM-54Cs coming of the production line. The team dismantled several missiles and found that production quality was unacceptable. Hughes was forced to shut down the facility. After seven months, $160 million in facility improvements and intense Navy monitoring the the facility was reopened.

The fact that Hughes changed the quality of the AIM-54C after contract award and the last major Navy review is an example of moral hazard. Hughes took advantage of the fact that the Navy would not monitor their facilities after the PAR. Since the AIM-54C contract was a FFP contract Hughes had an incentive to reduce quality to increase profits. Based on the analysis in Chapter III the Navy may have been able to avoid the quality problems by using an incentive contract. The contract could have been structured so that Hughes would be awarded with a higher fee if the missile exceeded quality specifications.
Chapter IV

The Concept of Asset Specificity

Transaction cost economics is based upon the behavioral assumptions discussed in Chapter II and the concept of asset specificity. The focus of this chapter will be to define asset specificity and show specific examples of the different forms of asset specificity as they relate to defense procurement.

Asset specificity is any investment in a specific piece of equipment, or skill, or parcel of land that is used to support a particular product, for a single user, and would not be acquired if the particular product was not produced. Four types of asset specificity have been identified within the transaction cost literature, but only three are relevant to defense contracting. They are physical asset specificity, human asset specificity and dedicated asset specificity.32

Physical asset specificity is any equipment

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32. The fourth type of asset specificity is site specificity. For more information about the different types of asset specificity see: Williamson, Oliver E., The Economic Institutions of Capitalism, New York: The Free Press 1987, p. 95-96.
dedicated to a specific product that has only one user. An excellent example of physical asset specificity within defense procurement would be aircraft tooling. Aircraft tooling consists of special dies, fixtures and test equipment, and is so specialized that it can only be used for a specific type of aircraft. Since, DOD is the only user of the aircraft the second best alternative for aircraft tooling would be scrap.

An example of human asset specificity would be any skill or special knowledge that that is directly related to a specific job and the knowledge cannot be transferred to another job. For example the mechanic who can only fix Nissan Pathfinders possess unique knowledge related to Pathfinders which cannot be transferred to fixing other types of cars. Within defense contracting "learning by doing jobs" such as factory workers on an assembly line is an excellent example of human asset specificity. These types of jobs are modeled by learning curve theory. The theory states that as a person performs a specific job a number of times they become more efficient and require less time to perform the job.\textsuperscript{33} The degree of specificity can be determined by the slope of the learning curve used to

\textsuperscript{33} For a more thorough discussion of learning curve theory see: Robbins, Jane, L., Cost Improvement Curve Analysis, August 1985
model the job. The alternative to working at that job would be another job which they would have to learn over, in terms of learning curve theory, the person would have to start at T-1.\textsuperscript{34}

A dedicated asset is an investment in a generalized production capability that would not be made, except for the prospect of selling a significant amount of production to a specific customer. An example of a dedicated asset is the autoclave used to produce composite parts for weapon systems. In the case of defense contractors the autoclave can be used across different weapon systems, but it was purchased to satisfy the primary need of one customer: DOD.

Asset specificity can be measured by determining the appropriable quasi rent associated with an asset. Klein, Crawford and Alchian describe appropriable quasi rent below:

"Assume an asset is owned by one individual and rented to another individual. The quasi-rent value of the asset is the excess of its value over its salvage value, that is, its value in its next best use to another renter. The potentially appropriable specialized portion of the quasi rent is the that portion, if any, in excess of its value to the second highest-valuing user. If this seems like a distinction without a difference, consider the following example.

\textsuperscript{34} T-1 is equivalent to the first time a person performs a specific job or task.
Imagine a printing press owned and operated by party A. Publisher B buys printing services from party A by leasing his press at a contract rate of $5,500 per day. The amortized fixed cost of the printing press is $4,00 per day and it has a current salvageable value if moved elsewhere of $1,00 (daily rental equivalent). Operating costs are $1,500 and are paid by the printing-press owner, who prints final printed pages for the publisher. Assume also that a second publisher C is willing to offer at most $3,500 for daily services. The current quasi rent on the installed machine is $3,000 (= $5,500 - $1,500 - $1,000), the revenue minus operating costs minus salvageable value. However, the daily quasi rent from publisher B relative to use of the machine for publisher C is only $2,000 (= $5,500 - $3,500). At $5,500 revenue daily from publisher B the press owner would break even on his investment. If the publisher were then able to cut his offer for the press from $5,500 down to almost $3,500, he would still have the press service available to him. He would be appropriating $2,000 of the quasi rent from the press owner. The $2,000 difference between his prior agreed to daily rental of $5,500 and the next best revenue available to the press once the machine is purchased and installed is less than the quasi rent and therefore is potentially appropriable. If no second party were available at the present site, the entire quasi rent would be subject to threat of appropriation by an unscrupulous or opportunist publisher.  

The $2,000 of potential appropriable quasi rent that the publisher could obtain through ex post contractual opportunistic behavior is commonly referred to in the contracting literature as the hold-up problem and will be the topic of chapter V.

The purpose of this chapter was to show the

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existence of different types of asset specificity within defense contracting. The next chapter will analyze the contractual problems that exist when asset specificity is prevalent.
Chapter V

The Hold-Up Problem in Defense Contracting

The focus of this chapter will be the effects of the hold-up problem as it relates to DOD contracting. The hold-up problem is an additional complication that DOD must consider when developing a contractual relationship with a manufacturer, that may also include adverse selection and moral hazard problems. DOD has tried to use competitive acquisition strategies to minimize the hold-up problem. At the end of this chapter is a case study to show the effects a competitive acquisition strategy can have on the hold-up problem.

The hold-up problem is present whenever asset specificity exists along with bounded rationality and opportunism. The example below will show that the hold-up problem is a problem of property rights, where the owner of the specific assets is at risk of losing the quasi rent stream associated with owning the specific assets.

Assume that the aircraft manufacturer pays for the specific physical and human assets needed to build an
aircraft.\textsuperscript{36} Once the manufacturer makes the investment he has committed to a long term relationship with DOD, but DOD has made no such commitment.\textsuperscript{37} Therefore, DOD may find it worthwhile to "hold-up" the next year's contract by appropriating some or all of the quasi rent stream generated from the specific assets.\textsuperscript{38} DOD could appropriate the quasi rent stream by reducing the unit cost of the aircraft.\textsuperscript{39} The manufacturers only recourse would be to refuse the offer or seek legal action. Both courses would result in costly losses to their manufacturer.\textsuperscript{40} Because of the potential hold-up problem the manufacturer may not fully invest in specific assets, which could lead to inefficient long term production.

To show the manufacturer that DOD is committed to a

\textsuperscript{36} Examples of specific physical and human assets were discussed in Chapter IV.

\textsuperscript{37} DOD typically only contract for single year procurement, because Congress only appropriates funding yearly.

\textsuperscript{38} In the 1980's the Secretary of the Navy tried to adopt a policy that would require Defense manufacturers to pay for all tooling cost and depreciate them like they would capital assets. The policy never was implemented mainly because of industry resentment. One possible explanation may be that industry was aware of the potential hold-up problem.

\textsuperscript{39} The quasi rent is equal to revenue minus operating expense minus salvage value.

\textsuperscript{40} Refusing the offer would lead to the loss of revenue generated by the aircraft program along with a reduction in business base. Court action would incur the same losses as refusing the offer plus court costs, but may result in a favorable decision for the manufacturer.
long term relationship, DOD pays for all of the physical and human specific assets.\textsuperscript{41} By investing in the specific assets, DOD is now at a disadvantage at contract renewal. Since DOD now owns the specific assets, the manufacturer can hold-up the renewal contract and appropriate the quasi rent stream by requesting higher unit aircraft prices.\textsuperscript{42} Because of the potential hold-up problem facing DOD, DOD has been searching for acquisition strategies other than sole source.\textsuperscript{43} Two alternative acquisition strategies would be competition or vertical integration. Both alternative strategies require additional cost above those of a sole source producer with the absence of the hold-up problem. Therefore, the strategies are not Pareto optimal and the additional cost are considered agency cost.

\textsuperscript{41} DOD pays for all of the tooling that is required and unique to the weapon system program but rarely assumes ownership. They pay for the human specific assets in the Full Scale Development (FSD) contract. In the (FSD) contract DOD pays the manufacturer to develop the weapon system and learns how to produce the weapon system. \textsuperscript{42} The quasi rent to the government is the cost associated with moving the physical specific assets and teaching new people how to build the aircraft. \textsuperscript{43} The acquisition strategy is the way DOD plans to procure a weapon system. Included within the acquisition strategy is the type of contract used to buy the weapon system. DOD has used two basic acquisition strategies: sole source (one manufacturer) and competition (more than one manufacturer, usually two).
DOD has used competitive acquisition strategies to reduce the unit price of a weapon system. A competitive acquisition strategy requires DOD to pay for two manufacturers to acquire the specific assets necessary to build the weapon system. By giving two manufacturers the specific assets needed to build a weapon system DOD hopes the competitive forces will reduce the cost increases due to appropriating the quasi rent stream to zero. For the competitive strategy to work the duplication cost must be less than the potential cost increases due to asset specificity. DOD has seen positive results from competition in missile systems. But, it should be noted that missile systems require few specific assets so the duplication costs are low. For other weapon systems like aircraft which require large amounts of specific assets it is not clear that the duplication cost are less than the cost increases due to the hold-up problem. To date no DOD aircraft program has used a competitive acquisition strategy. Navy competition studies for aircraft have not shown that competition will reduce aircraft cost enough to make up for the duplication costs.\footnote{Unpublished Navy competition studies for the V-22 and A-12 aircraft have not shown any cost benefit based on competing the prime aircraft manufacturers. The duplication costs in the studies have been greater than the potential savings due to the hold-up problem.} The Navy and the Air force are requiring, for new aircraft programs, that
the manufacturer develop a competitive strategy for subsystem level components so that the appropriable quasi-rent stream is limited to specific assets related to the assembly of the aircraft.45

The second alternative to sole source acquisition strategy could be vertical integration where DOD would buy the capability to develop and manufacturer its own weapon systems. Vertical integration results in organizational cost which Coase realized.

"First, as a firm gets larger, there may be decreasing returns to the entrepreneur function, that is, the costs of organizing additional transactions within the firm may rise. Naturally a point must be reached where the costs of organizing an extra transaction within the firm are equal to the costs involved in carrying out the transaction in the open market, or, to the costs of organizing by another entrepreneur. Secondly, it may be that as the transactions which are organized increase, the entrepreneur fails to place the factors of production in the uses where their value is greatest, that is, fails to make the best use of the factors of production. Again, a point must be reached where the loss through the waste of resources is equal to the marketing costs of the exchange transaction in the open market or to the loss if the transaction was organized by another entrepreneur. Finally, the supply price of one or more of the factors of production may rise, because the "other advantages" of a small firm are greater than those of a large firm. Of course, the actual point where the expansion of the firm ceases might

45. The Navy NATF and the Air Force ATF, both currently in milestone I, have required competitive subsystems strategies from the competing manufacturers. Aircraft subsystems are generally made of general purpose assets.
be determined by a combination of the factors mentioned above. The first two reasons given most probably correspond to the economists' phrase of 'diminishing returns to management.'

DOD currently owns the ability to develop and produce weapon systems which require small amounts of specific assets. It does not own the same capability for systems that require large amounts of specific assets. Although I know of no study which has examined vertical integration within DOD such a study could prove interesting results. Given the current size of DOD, however, it is reasonable to assume that vertical integration would result in diminishing returns to management and the cost associated with organizing the additional transactions would be greater than the cost associated with the hold-up problem.

In this chapter the affects that asset specificity have on DOD acquisition strategies has been discussed. It was found, that asset specificity created the hold-up problem which caused DOD to use a non Pareto optimal acquisition strategy. The strategy that showed the greatest advantages to DOD was the competitive strategy. The alternative strategy, vertical integration, appears to

47. The Naval Avionics Center in Indianapolis, Indiana has built avionics equipment for the Navy.
create organizational costs which are greater than the cost associated with the hold-up problem. Although further studies identifying the organizational cost should be conducted before vertical integration can be ruled out completely. The final chapter outlines the results from this study.
Section V.1
The Phoenix Missile, Competition and the Hold-Up Problem

The Hughes Aircraft Company was the sole source producer of the Phoenix missile (AIM-54C) since inception in 1980. Due to the high unit missile price the Navy decided to add a second source to produce the missile with the hope of reducing unit missile price. The Raytheon Company was selected as the second source manufacturer in 1986. In 1986 Raytheon was directed to produce ten AIM-54Cs for learning purposes, fifty six to validate that the missile was built properly and preformed like the Hughes version, and 180 AIM-54Cs so that they could gain the necessary experience to effectively compete. In 1989 the first head to head competition between Hughes and Raytheon resulted in a seventeen percent decrease in the unit missile price relative to the Navy's projected unit missile price if Hughes had no competitive pressure.

When Hughes was the only producer of the AIM-54C

they were able to "hold-up" the Navy for the appropriable portion of the quasi rent stream associated with the specific assets. The specific assets included the unique AIM-54C tooling and test equipment along with the unique human specific assets associated with Hughes' knowledge of how the AIM-54C is built. When Raytheon became capable of producing the AIM-54C Hughes could no longer "hold-up" the Navy for the quasi rent stream, to due so would result in Hughes producing fewer missiles which would result in lower profits and a lower business base. The seventeen percent decrease in missile price can be seen as the cost associated with the hold-up problem. Therefore, the competitive pressure reduced the cost associated with the hold-up problem.
Chapter VI

Conclusion

The principal findings of this study are: 1) the key elements of the transaction cost paradigm do apply to defense contracting, 2) the paradigm can be used as a framework to evaluate defense contracts and related problems. The key elements of the transaction cost paradigm are bounded rationality, opportunistic behavior, and asset specificity.

The high costs associated with collecting and evaluating information related to weapon systems has forced DOD to select manufacturers based on incomplete information, which is a form of bounded rationality that can lead to adverse selection problems. The use of a FFP contract which shift the majority of the program risk onto the manufacturer was seen as a possible solution to the adverse selection problem. The P-7 case study was an example of a program that used a FFP. The results of the case study indicate that the FFP contract did not reduce the adverse selection problem.

Due to the high cost of monitoring defense
manufacturers DOD often does not have the resources to properly monitor the manufacturers enough to prevent opportunistic behavior, of the moral hazard type. The type of moral hazard experienced most by DOD is reduced quality control once the weapon system is being produced at high rates. Moral hazard related to quality control was examined in the Phoenix missile case study. The cause of the moral hazard could be linked to the FFP contract, used by the Navy, which gave the manufacturer incentive to reduce quality to increase profits. When the Navy noticed the reduced quality they increased their monitoring efforts. Based on the analysis in Chapter III the Navy could have used an incentive contract to reduce the moral hazard problem.

The last element in the transaction cost paradigm, asset specificity, was also determined to be prevalent in defense contracting and can cause a hold-up problem. The hold up problem is caused by the manufacturer "holding-up" DOD for the quasi rent stream generated by specific assets. This can lead to weapon system prices that are over stated because they include some or all of the appropriable quasi rent. In the Phoenix missile case study, in Chapter V, a competitive acquisition strategy was used to reduce the hold-up problem related to the AIM-54C.
The results of this study concluded that the transaction cost paradigm is a reasonable framework for evaluating the problems related to defense contracting and their solutions.
Appendix A

ACQUISITION

The acquisition of DOD weapon systems is event driven and follows a milestone schedule. Milestones are go/no-go decisions made by the decisions authority at key program transition points. The decision authority is either the Secretary of Defense (SECDEF) or the Service Secretary depending on the cost of the weapon system program. The length of time between milestones differs depending on the weapon system program. Weapon system programs can not proceed to the next milestone until the decision authority deems that the program has successfully fulfilled the events in the previous milestone. The milestone decision includes thresholds and other criteria to be satisfied by the next milestone.

The start of a new weapon system program begins with a Justification for Major System New Start (JMSNS) paper and a Program Objective Memorandum (POM) submitted to the SECDEF by the Service sponsoring the weapon system. Once the POM is approved by the SECDEF a Program Decision Memorandum is provided, which officially sanctions the new start and authorizes the service to initiate the next program phase.
The concept formulation phase is a preliminary evaluation of different system concepts, cost, schedule, readiness objectives, and affordability of the weapon system. The service acquires the data for the alternative system concepts through a Request for Information (RFI). The RFI is sent out to industry and includes the Tentative Operational Requirement (TOR), threat information and cost instructions. RFI responses are usually at no cost to the government and are not subject to the same limitation as a Request for Proposal (RFP). Once the RFI responses are received by the government they are reviewed and evaluated. After the evaluation the information is used to refine the TOR, cost estimates, and schedule. An affordability analysis will also be performed during this phase of the program. Based on the type of weapon system a source selection will be held to reduce the number of contractors for milestone I Demonstration and Validation (DEMVAL). The source selection requires a formal RFP. During this stage of the program the RFP will usually consist of an updated TOR and included threat information and cost instruction. The results of the RFP will be evaluated and the winners will be awarded a DEMVAL contract. At this point in the weapon system program more than one contractor will usually be awarded a DEMVAL contract.
The objective of the DEMVAL phase is to reduce the technical and operational risk to an acceptable level so the program can enter the next milestone phase. To achieve the DEMVAL objective the contractors will build prototype systems to demonstrate there ability to develop and manufacture the weapon system. Up until this phase in the program the weapon system concepts are engineering models and paper designs. Once the prototypes are built they will be used to validate the engineering models used by the contractors. After the DEMVAL work is completed a source selection will be held and one contractor or contractor team will be chosen to enter milestone II. The data from the DEMVAL program will be used in the contractors RFP response. The contractors RFP responses will be evaluated by the government based on technical and cost criteria. The winner will be the lowest cost design that fully meets the technical requirements of the weapon system. A design cannot win the competition unless it fully meets the technical requirements.

The milestone II decision FSD is the most critical milestone because it represents a firm commitment to the program by the service. During FSD full scale weapon systems are built and tested to show that the weapon system meets the services technical and operational requirements.
For acquisition category I (ACAT I) programs FSD can last up to ten years and cost billions of dollars. The program cannot enter milestone III Full Scale Production until all the requirement are fully meet to the services satisfaction.

Milestone III is often broken up into two phases milestone IIIa Limited Rate Production (LRP) and milestone IIIb Full Rate Production (FRP). During LRP the first operational weapon systems are produced. During LRP the contractor is developing ways to make the weapon system more producible. Although producibility is always a factor in weapon system design it is not the main objective of any milestone until LRP. Once the weapon system has proved that it is producible it enters FRP. Once in FRP the weapon system will continue to be produced until a replacement system is develop or the threat that the system was designed to counter becomes insignificant.
Appendix B

DOD Planning, Programming and Budgeting System

The Planning, Programming and Budgeting System (PPBS) is a cyclical process which starts each year with the development of the joint planning document and ends with the submission of the President's budget to Congress. The intent of this section is not to explain the PPBS process in detail but to give a feel for the complexity and uncertainty that exists within the process.

The planning phase is the first phase of the PPBS process and is performed at the OSD level. The objective of the planning phase is to identify mission needs and define a planning force. Before the planning force can be defined a national defense strategy must be developed. The defense strategy is based on an appraisal of the current threat, the national defense policy, and the United States role in International policy including NATO obligations. The persons responsible for the development of defense strategy and the planning force are the Joint Chiefs of Staff, President of the United States, and the Defense Resource Board. Once the planning force is developed the individual services take their requirements and enter the programming phase.
The programming and budget phases are performed at the service level. The objective of the programming phase is to translate the planning forces and fiscal guidance constrains into weapon system programs. The results of the programming phase make up the Program Objectives Memorandum (POM) which is submitted to OSD by the service secretaries. The POM is the only opportunity to put money into the defense budget for new program starts or to change the budget for existing programs. The POM is also the services first iteration at describing and pricing the planning force without firm budgetary constrains. The next phase in the PPBS process is the budgeting process which derives the costs associated with the POM.

Although the services have similar budget processes there are minor differences in procedures, therefore, the Department of the Navy's budget process will be used as an example. The budget process is a iterative process that fine tunes the POM and the end product is the President's budget. The budget process can be broken up into four distinct phases: the POM, Navy Comptroller's Budget (NAVCOMPT), OSD budget, and the President's budget. The three budgets (NAVCOMPT, OSD, President's) follow a similar process that starts with the review and analysis of the preceding submission. The order of submissions are current
POM, NAVCOMPT, OSD, and Presidents budget.

During the NAVCOMPT budget the Navy will look at all of its weapon system programs costs. Then the Navy Comptroller will prioritize the weapon systems based on the primary objectives of the Navy as described by the planning force. Then the comptroller will make adjustments to POM submissions based on fiscal constrains handed down from OSD and the Navys priorities. The comptrollers adjustments are referred to as program control totals. The adjustments can include fully funding the program to cutting the program out of the Navy budget. Once the adjustments are submitted to the weapon systems program offices the program offices have an opportunity to reclama the recommended adjustment. During the reclama period a series of "what if drills" are performed to show what effects the control totals have on the weapon system program. "What if drills" normally include sensitivity analysis of what can be purchased for a given dollar amount, to analysis of what it will cost to procure a given number of a weapon systems. After the reclamas have been reviewed a final NAVCOMPT budget is approved and submitted to OSD.

Once OSD receives the budget submissions from the different services (Navy, Air Force, Army) they are
reviewed and analyzed. After the analysis is complete OSD prioritizes all the weapon systems; within DOD based on planning force and fiscal constrains levied by the executive branch. The adjustments cover a wide range of alternatives from fully funding a program to canceling the program. Once the adjustment are handed down to the program offices a series of "what if drills" are preformed similar to what was done during the NAVCOMPT budget. The program offices can also reclaim the dollar totals given them. After the reclama's are received and reviewed a final OSD budget is approved and submitted to the President.

The President's budget goes through the same review cycle as the NAVCOMPT and OSD budgets. The prioritizing for the President's budget involves the national budget priorities. Once the President's budget is approved it is submitted to Congress. Congress will go through the DOD budget line by line and appropriate money for the different programs. Once the money is appropriated and congress and the President pass the budget the money can be spent by the program offices.

The budget process involves a series of optimization decisions during each budget submission. The optimization decisions cover a broader range of decisions as the budget process progress from the services budget to the Presidents
budget. As the budget process progress the decisions made can change dramatically from one budget submit to the next, which creates uncertainty within the weapon system program. This uncertainty inherent in the budget process effects the program offices ability to effectively plan and award defense contracts.
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VITA

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