

NAVAL POSTGRADUATE SCHOOL

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THESIS

SURVEY OF DOD PROFIT POLICY AND FURTHER ANALYSIS OF THE ESTIMATION THEORY

by

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December 1999

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**SURVEY OF DOD PROFIT POLICY AND FURTHER
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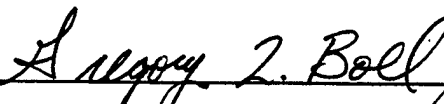
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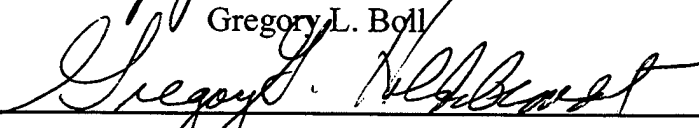
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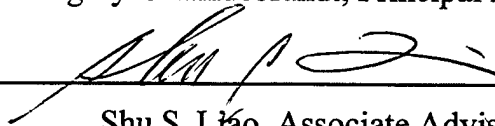


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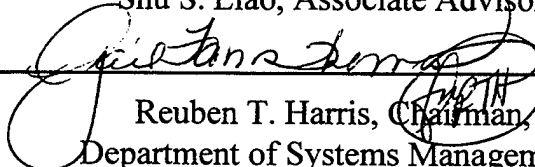
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ABSTRACT

The current weighted guidelines profit policy within the Department of Defense (DOD) has been the subject of numerous studies over the past four decades to determine its effectiveness within DOD. Many of the studies offer differing results as to the effectiveness of this policy and the measurements used for analysis. The central objective of this study was to conduct a survey of the weighted guidelines profit policy and use event analysis to estimate the size of prizes awarded to defense contractors. To address this issue, a survey of the weighted guidelines profit policy was completed with consideration of an economic approach to the weighted guidelines policy. Analysis of four missile defense systems was conducted to measure the size of prizes awarded for missile contract awards. Findings of the study are limited. The present profit policy within DOD can be improved upon with an economic approach to the weighted guidelines profit policy. However, conclusive findings were not observed for analysis of economic profit within the defense missile industry. This was due to the limited number of contests analyzed in this study.

TABLE OF CONTENTS

I.	INTRODUCTION	1
A.	GENERAL OVERVIEW	1
B.	OBJECTIVES OF RESEARCH.....	2
C.	SCOPE AND LIMITATIONS	2
D.	RESEARCH QUESTION	3
E.	ORGANIZATION OF THE STUDY	3
II.	DOD PROFIT POLICY	5
A.	HISTORY OF PROFIT POLICY	5
B.	WEIGHTED GUIDELINES POLICY.....	7
1.	Performance Risk	7
2.	Contract Type Risk.....	8
3.	Working Capital Employed.....	9
4.	Facilities Capital.....	11
C.	EFFECTIVENESS OF POLICY.....	12
III.	CAPTIAL ASSET PRICING MODEL OF DOD PROFIT	19
A.	OVERVIEW	19
B.	CONTRACT RISK AND WORKING CAPITAL.....	19

1.	Pure Production Contract	20
2.	Pure Financing Contract.....	20
C.	APPLICATION OF MINIMUM PROFIT RULE	21
D.	SIMILIARITIES OF CAPITAL ASSET PRICING MODEL	21
E.	APPLICATION OF THE CAPM TO WEIGHTED TO THE WEIGHTED GUIDLELINES POLICY	24
1.	Pure Production Contract Portion.....	25
2.	Pure Financing Contract Portion	25
F.	RECOMMENDED CHANGES	27
IV.	ESTIMATION THEORY.....	29
A.	BACKGROUND	29
B.	THE MODEL	30
C.	APPLICATION OF THE MODEL.....	31
V.	DATA COLLECTION AND ANALYSIS.....	33
A.	OVERVIEW	33
B.	METHODOLOGY AND MODEL	34
C.	TOMAHAWK SYSTEM	36
1.	Conclusion.....	36
D.	HARM SYSTEM	38
1.	Conclusion.....	39

E.	HARPOON SYSTEM.....	40
1.	Conclusion.....	41
F.	SPARROW SYSTEM.....	42
1.	Conclusion.....	43
VI.	SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	45
A.	SUMMARY	45
B.	CONCLUSIONS	45
C.	RECOMMENDATIONS	46
1.	Recommendations for Further Action.....	46
2.	Recommendations for Further Study	46
	LIST OF REFERENCES.....	49
	BIBLIOGRAPHY.....	51
	INITIAL DISTRIBUTION LIST	53

LIST OF TABLES

Table 1.1.	Performance Risk Sub-Elements.....	8
Table 1.2.	Contract Type Sub-Elements.....	8
Table 1.3.	Contract Length Factors	10
Table 1.4	Facilities Capital Sub-Elements	11
Table 1.5	Summary of Academic Studies	13
Table 1.6	Industry and Company Profit Measures	14
Table 1.7	Debt/Equity Ratios	16
Table 5.1	Missile System Contracts	33
Table 5.2.	TOMAHAWK Missile System	37
Table 5.3.	HARM Missile System.....	39
Table 5.4.	HARPOON Missile System	41
Table 5.5.	SPARROW Missile System	43

I. INTRODUCTION

A. GENERAL OVERVIEW

Is there evidence of excessive profits within the defense industry? And if so, are there alternative measures that can be used to calculate profit for defense contractors? These questions have been asked for the past forty years. In trying to answer them numerous studies have been conducted by both the government and private agencies with conflicting results from both (Kaun, 1988, p. 2). However, several measures exist for determining profit within the defense industry which lead to higher or lower measures of profitability for defense firms depending on which measure is applied. These measures include the current weighted guidelines policy and Rogerson's approach to the weighted guidelines policy using a capital asset pricing model approach.

Both models are examined in the following chapters to provide a better understanding of the factors included to determine profit within each. Finally the amount of economic profit earned by defense contractors is analyzed for the missile industry using the estimation theory model. This model provides a method of measuring economic profit by using stock market data in "event analysis" to measure the size of the prize that defense contractors receive from contracts. By observation of stock prices before and after the award of the contract, an estimate

of the size of the economic profit that a firm receives from a defense contract can be estimated.

B. OBJECTIVES OF RESEARCH

The purpose of this research is to obtain a better understanding of the current profit policy and consider an alternative model that can be utilized to determine profits for defense contractors. Additionally the estimation theory for measuring the size of economic profit earned on defense contracts will be presented and analyzed using missile firms within the defense industry. It will address the amount of economic profit earned on defense contract awards.

C. SCOPE AND LIMITATIONS

The focus of this research will be limited to the survey of the current and alternative profit policy models based on available literature. It also examines the size of economic profit earned for defense contractors within the defense missile industry on specific missile system contracts. This research does not address the question of whether or not the amount of economic profit earned on those contracts is excessive or not.

D. RESEARCH QUESTION

The primary research question of this research is as follows: Is the "event analysis" model applicable to the missile defense industry and how significant are the amounts observed?

The following are the secondary research questions:

1. Does data suggest that insider trading takes place before the announcement causing prices to rise?
2. Does the data suggest that the market learns that a winner will be announced sometime before the announcement day?

E. ORGANIZATION OF THE STUDY

This study consists of six chapters. Chapter I contains an introduction to the thesis. Chapter II provides a history of profit policy in the defense industry and presentation of the weighted guidelines profit policy model. The third chapter presents the capital asset pricing model approach to the weighted guidelines policy. The fourth chapter looks at the estimation theory model and the use of stock market data in the estimation of prize awards. Chapter V identifies the missile systems and firms included in the study and analysis of data for each. The sixth chapter provides a summary, conclusions and recommendations from this research.

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II. DOD PROFIT POLICY

A. HISTORY OF PROFIT POLICY

The Department of Defense has struggled with profit regulation since the Revolutionary War (Short, 1993, p. 915). Excessive profits had become a problem and resulted in the passage of Government statutes requiring purchasing officers to advertise for competitive bids in procurement of defense goods (LMI, 1968, p. 8). Those statutes governed profit policy over the next 100 years.

Profit policy became an issue again during World War I as the nation rapidly mobilized and required major procurements. During this time a cost-plus-a-percentage-of-cost method was used resulting in considerable profits for firms. One example was Bethlehem Steel, which was alleged to have earned an 18% return on sales for ship construction contracts. (Burns, 1972, pp. 5-6) Eventually the Vinson-Trammell Act of 1934 was enacted which limited profits to 12% for aircraft and 10% for shipbuilding. However with the U.S. mobilizing for World War II, standards were eased and contractors were again able to realize large profits.

The Renegotiation Act of 1943 was passed in an effort to renegotiate prime and subcontracts in excess of \$100,000 in an effort to recoup excessive profits. The Navy and War secretaries were tasked with carrying out the renegotiations until 1951 when a second Renegotiation Act was passed which established an

independent agency, The Renegotiation Board, to oversee contractor profits. The board was tasked with reviewing all firms doing at least one million dollars in business with DOD and other governmental departments. (Burns, 1970, p. 308)

In 1947 the Armed Services Procurement Act (ASPA) was passed which outlined nine profit elements to be considered in contract negotiations:

1. The amount of effective competition;
2. The degree of risk;
3. The nature of the work to be performed;
4. The extent of government assistance;
5. The extent of contractor's investments;
6. The character of the contractor's business;
7. The firm's historical performance on contracts;
8. The degree of subcontracting;
9. The degree of realism in a contractor's cost estimates. (Wight, 1984, p. 7)

However, little progress was achieved as application of the above elements was left up to contractor preference. Eventually congress enacted a new approach called the Weighted Guidelines profit policy.

B. WEIGHTED GUIDELINES POLICY

The Weighted Guidelines (WGL) policy was adopted and implemented on 1 January 1964. It provided for a more structured approach to developing profit objectives based on specific guidelines. These guidelines were later revised in 1976, 1980 and 1987. The method is broken down into four primary areas discussed below.

1. Performance Risk

This factor addresses the "contractor's risk in fulfilling the contractual requirements to provide the supplies or to perform the services being acquired" (US Commission on Government Procurement, 1972, p. 215). The following are sub-elements within this category:

1. Technical- deals with the level of technology being applied or developed by the contractor.
2. Management- considers the management effort in the effective use of resources and value-added activities by management.
3. Cost Control- the effort of the contractor to reduce costs is assigned.

Based on the above sub-elements the contracting officer assigns percentage weights, which total to 100%. Then separate values are selected for the sub-elements based on perceived risk within each element for the contractor. The range of values to assign is as follows:

Table 1.1. Performance Risk Sub-Elements

<u>Sub-Element</u>	<u>Normal Value</u>	<u>Allowable Range</u>
Technical Risk	1.2%	0.6% to 1.8%
Management	1.2%	0.6% to 1.8%
Cost Control	1.6%	0.8% to 2.4%
Total	4%	2% to 6%

The assigned values are then multiplied by the assigned weights for each element.

The three figures are then totaled together to yield the value of Performance Risk.

2. Contract Type Risk

This factor considers the degree of cost risk taken on by the contractor for various contract types. This includes working capital adjustments for fixed-price contracts. The following is a breakdown of contract types and allowable ranges for those categories.

Table 1.2. Contract Type Sub-Elements

<u>Contract Type</u>	<u>Normal Value</u>	<u>Allowable Range</u>
Firm Fixed-Price	3%	2% to 4%
Fixed-Price-Incentive or Cost-Plus-Incentive	1%	0% to 2%
Cost-Plus-Fixed-Fee	.5%	0% to 1%

Some clarification of the previous sub-elements is needed. A firm fixed price contract is where the firm bears all the risk. A cost plus fixed fee contract is where DOD bears the risk. Fixed price incentive and cost plus incentive fee contracts permit the risk shared between the Government and the contractor.

In evaluation of the contract type risk, the government should consider length of the contract, adequacy of cost data projections, the economic environment, subcontractor activity and any protection provided to the contractor as identified within the contract provisions. As with performance risk the government may assign a higher or lower value than normal based on the contract conditions.

3. Working Capital Employed

For contracts with provisions for progress payments, the contracting officer makes a working capital adjustment. The underlying premise of this adjustment is to recognize the contractors cost of working capital under varying conditions. However the intent is not to calculate exact costs for working capital. The calculation is made by multiplying the contract costs financed by the contractor by a contract length factor and then by an interest rate established by the Treasury Department. For fixed price contracts where progress payments are common the following equation is derived.

$$R_T L(l) E(c) (1-\alpha) \quad (1.1)$$

where:

R_T = Treasury Rate

$L(I)E(c)(1-\alpha)$ = a function of the contract length
times estimated costs times 1 minus
the progress payment rate

The following is a table to determine the contract length factor.

Table 1.3. Contract Length Factors

<u>Period to Perform</u>	
<u>Substantive Portion</u>	<u>Factor</u>
21 months or less	.4
22 to 27 months	.65
28 to 33 months	.90
34 to 39 months	1.15
40 to 45 months	1.40
46 to 51 months	1.65
52 to 57 months	1.90
58 to 63 months	2.15
64 to 69 months	2.40
70 to 75 months	2.65
76 months or more	2.90

In determining the contract length factor, the contracting officer should only consider the time period in which the contractor invests working capital. The final working capital adjustment may not exceed 4% of contract costs.

4. Facilities Capital

Facilities capital is focused on encouraging contractors to invest facilities capital that will benefit DOD. The three sub-elements considered are land, buildings and equipment. The book value of these investments is considered along with the contractor's formal investment plan if the contractor has demonstrated the benefits DOD will receive from the investment. The treasury rate is applied to the book value for all contracts for each year the facilities capital is used on the contract. In addition to the treasury rate, the regulations also allow for an additional return above the treasury rate to be applied to facilities capital utilized. The following is a breakdown of those facilities capital values.

Table 1.4. Facilities Capital Sub-Elements

<u>Sub-Element</u>	<u>Normal Value</u>	<u>Allowable Range</u>
Land	0%	0%
Buildings	15%	10% to 20%
Equipment	35%	20% to 50%

C. EFFECTIVENESS OF POLICY

Determining the effectiveness of the weighted guidelines policy has been difficult at best. In a government study directed by congress in 1969, the GAO found profits earned on defense contracts during the period of 1966-69 to be comparable to profits earned on commercial contracts and recommended no legislative changes be enacted for DOD profit policy (GAO Defense Industry Profit Study, 1971, p. 1). However, this same agency changed its view over two decades later and argued that defense contractors were 35 percent more profitable than commercial firms from 1970-79 and 120 percent more profitable than commercial firms from 1980-83 (GAO Defense Industry Profit Study, 1986, p. 3). There is no evidence to account for this substantial increase in profits for defense firms with respect to commercial firms over this time period. The only plausible explanation is that the method used to measure the level of profits varies with respect to time periods, the sample of firms, the sample of contracts, as well as measures of profitability utilized across different studies (Kaun, 1988, p. 5).

Academic studies have rendered similar results. The following table outlines various studies with mixed results obtained (Kaun, 1988, p. 6).

Table 1.5. Summary of Academic Studies

Author	Year	Nature of Data	Defense Profits Relative to Commercial
E.F. Leatham	1958	Nat Sec. Indust Assoc.	Substantially less
M.J. Peck & F.M. Scherer	1962	3 def industries, all mfg	Generally higher
V. Perlo	1963	15 def firms; Fortune 500	Substantially higher
M. Weidenbaum	1968	6 def firms, 6 non-def firms	Higher
A.M. Agpos & L.E. Gallaway	1970	23 large def firms, all mfg	No evidence of excessive profits
G. Stigler & C. Friedland	1971	Firms with 10% or more sales to DOD, 3500 comm firms	More profitable in 1950s less in the 1960s
S.L. Carroll	1972	7 maj aircraft firms, all mfg	Extremely high
L.H. Goodhue	1972	4 maj industries, all mfg	Little variation
D.R. Bohi	1973	36 def firms, 500 largest mfg firms	Similar
Forbes	1978	5-year average by 30 major industries	Among the most profitable
J.S. Gansler	1980	35 def firms, 208 comm durable goods firms	Less
S. Martin	1982	209 detailed industries	Similar
J. Reppy	1983	64 def firms, 5000 mfg firms	Similar

An example of one of these studies is illustrated. The study looked at the government-oriented airframe firms versus the commercial airliner industry. (Carroll, pp. 545-562) Seven airframe firms were considered overall as the airframe industry and further broken down into commercial and government-oriented sectors. Industry sales and equity were noted for all firms. A return on invested capital as a profit measure was also analyzed with special attention given to comparisons and the effect of risk on the required rate of return. Table 1.6 provides a summary of industry profits as a percentage of stockholders' equity in relation to all manufacturing firms. The seven firms were broken down into government-oriented firms and commercial airline producers.

Table 1.6. Industry and Company Profit Measures

Sector and Measure	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Mean	Std Dev
Profits/Equity ^a												
Industry												
All Manufacturing	11.0	8.6	10.4	9.2	8.8	9.8	10.2	11.6	13.0	13.5	10.6	
Aircraft & parts	17.7	13.1	8.2	7.4	9.8	12.7	11.3	12.2	13.0	15.1	12.0	
Seven Firms ^b	18.7	13.2	5.6	-2.1	-3.0	17.1	17.0	15.5	17.6	14.3	12.5	8.41
Gov-Oriented Firms												
North American	19.9	14.5	15.0	11.0	12.1	14.2	15.5	16.7	14.4	14.2		
McDonnell	26.7	22.2	18.7	19.1	16.8	16.7	17.4	20.6	21.5	22.8		
Grumman	7.7	5.2	9.9	13.4	10.8	10.5	11.8	14.8	23.3	24.3		
Combined ^b	18.5	14.2	14.8	12.9	12.8	14.1	15.4	17.4	17.7	18.5	15.6	2.08
Comm-Airline Producers												
General Dynamics	19.7	13.4	9.4	-9.4	-122.0	31.0	32.2 ^c	14.2	17.4	20.4		
Lockheed	14.1	13.6	5.9	-42.0	19.8	28.4 ^d	20.6	18.9	18.6	18.5		
Boeing	21.3	14.6	6.0	10.3	13.8	10.0	7.5	14.8	21.0	13.5		
Douglas	18.2	9.6	-24.0	-16.0	4.7	7.5	8.0	8.5	8.3	-16.0		

Table 1.6 (Continued)

Sector and Measure	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Mean	Std Dev
Combined ^b	17.8	12.8	2.2	-8.7	-12.0	18.6	17.8	14.6	17.5	12.4	9.3	10.08
a Profits are net income + net nonrecurring income. Equity = common equity + preferred stock + intangibles.												
b Defense commercial, and seven-firm ratios are computed as (sum of profits/ sum of equity).												
c Includes \$33 million from reduction on losses in 1961.												
d Includes \$13 million gain on sale of Trans-American Stock less related taxes.												

As seen in the profits-to-equity ratios above, the overall airframe industry surpassed all manufacturing firms during the period. Additionally, within the seven airframe firms, the government-oriented firms display a higher profits-to-equity ratio than the commercial airline producers. Carroll considered that this may have resulted from risk premiums that are required in a free capital market with risk-averse lenders as insurance against bankruptcy. (Carroll, p. 549) The two principle causes for this high risk are (1) volatility and uncertainty of profits and (2) high leverage. However, the volatility and uncertainty of profits in the government airframe industry is contrary to observed results. The government-oriented firms displayed a mean return of 15.6 percent with a standard deviation of 2.08 in contrast to the commercial airframe producers, which displayed a lower mean of 9.3 and a standard deviation of 10.08. This then would lend itself to the government contractors having a more stable and less risky return than the commercial airframe producers.

The high debt-to-equity ratios were next considered as a cause for the higher than normal profits. The following table presents the debt to equity ratios for the total firms, government-oriented firms and the commercial firms.

Table 1.7. Debt/Equity Ratios

Sector	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Seven Firms	0.135	0.225	0.247	0.245	0.264	0.232	0.230	0.197	0.175	0.290
Government	0.065	0.041	0.031	0.010	0.005	0.023	0.044	0.038	0.044	0.046
Commercial	0.159	0.274	0.306	0.316	0.352	0.307	0.297	0.256	0.228	0.368

Note: Equity = common equity + preferred stock + intangibles. Debt = long-term debt.

Clearly the leverage for the government airframe contractors is lower than the commercial firms. In fact the leverage for the government firms is significantly lower than all manufacturing firms in 1963, who averaged 0.254. (Carroll, p. 550) This would then eliminate the premise that government firms earn a higher profit due to high debt-to-equity ratios.

Carroll concludes that the government airframe sector achieved greater gains in a rapidly growing government airframe industry. He goes on to attribute the large losses in the commercial sector to the large expenditures by the commercial airframe producers in research and development. Resources were not optimized to the extent that firms excessively duplicated one another's efforts in research and development.

In light of the previous government and academic studies, it becomes clear that determining the effectiveness of the present profit policy within DOD is inconclusive. Depending on which study you utilize and the methodology inherent in that study, a wide range of results can be attained. Further determination of the effectiveness of this policy is beyond the scope of this research.

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III. CAPITAL ASSET PRICING MODEL OF DOD PROFIT

A. OVERVIEW

Another way of looking at profit policy within DOD is through an application of the capital asset pricing model. William Sharpe, John Linter, and Fisher Black (Malkiel, 1996, p. 241) devised the capital asset pricing model (CAPM). Sharpe later received the Nobel Prize for his contribution in 1990.

In a nutshell, the CAPM says that returns (and, therefore risk premiums) for any stock will be related to beta, the systematic risk that cannot be diversified away (Malkiel, 1996, p. 244). Rogerson (1992) has taken an economic look at DOD profit policy and derived formulas with the same characteristics as the CAPM. A summary of this application is presented here (Rogerson, 1992, pp. xi-xvii).

B. CONTRACT RISK AND WORKING CAPITAL

A contract with the government is presented in the following form where $p(C)$ is the governments promised payment to the firm based on cost outcome C . Costs are incurred on the contract for years 1 through L with delivery in year L . The equation is as follows:

$$p(C) = \pi + E(c) + (1-\gamma)[C-E(c)] \quad (3.1)$$

Where:

π = profit,

γ = the firm's share of the risk for cost overruns or underruns,

c = the random cost to be incurred,

$E(c)$ = expected cost

More formally the contract can be represented as a triple (π, γ, α) . The contract presented above can be further broken down into two separate subcontracts. One is a production contract defined as pure production contract (PPC) and the other is a financing contract defined as pure financing contract (PFC). The following is an explanation of each.

1. Pure Production Contract

A pure production contract is one in which the firm bears all the risk of cost overruns or underruns but none of the financing costs. During the course of the contract the government pays the contractor the costs, C . The government pays the firm the following at time L when the item is delivered:

$$\pi_{PPC} = \pi + \gamma [E(c) - C] \quad (3.2)$$

Formally this is represented as $(\pi, \gamma, 1)$.

2. Pure Financing Contract

A pure financing contract is one in which the firm bears none of the risk of cost overruns or underruns but supplies $(1-\alpha)$ of the financing. The government pays the firm the following at time L :

$$\pi_{PFC} = (1-\alpha) C + \pi \quad (3.3)$$

Where:

α = progress payment rate which is between $[0,1]$

Formally this is represented as $(\pi, 0, \alpha)$.

A contract (π, γ, α) then can be viewed as two separate contracts that have π_{PPC} and π_{PFC} .

C. APPLICATION OF MINIMUM PROFIT RULE

We can let $\pi^*(\gamma, \alpha)$ denote the minimum profit that a firm is willing to accept for a contract. Based on the above formulation then, the following is calculated:

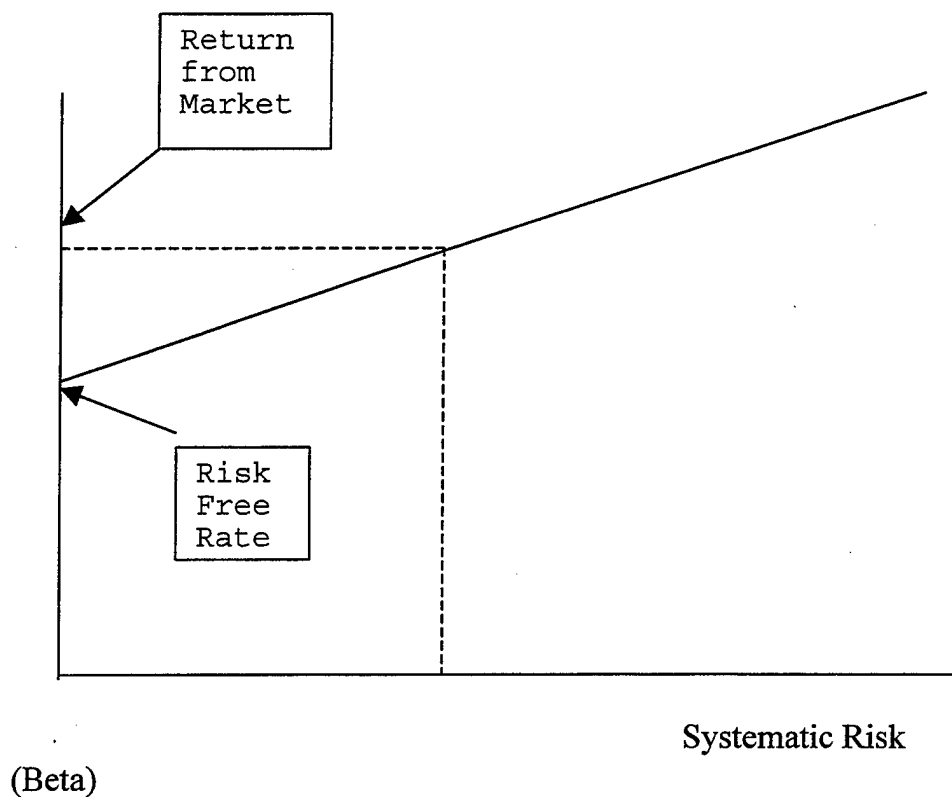
$$\pi^*(\gamma, \alpha) = \pi^*_{PPC}(\gamma, \alpha) + \pi^*_{PFC}(\gamma, \alpha) \quad (3.4)$$

The profit required for PPC can be thought of as payment for contract risk and the profit required for PFC can be thought of as payment for working capital.

D. SIMILIARITIES OF CAPITAL ASSET PRICING MODEL

As mentioned earlier, the capital asset pricing model says that returns for any stock will be related to beta, the systematic risk that cannot be diversified away. Graphically this can be represented as follows: (Malkiel, 1996, p. 248)

Rate of Return



The equation for the above line is as follows:

$$\text{Rate of Return} = \text{Risk-free Rate} + \text{Beta}(\text{Return from Market} - \text{Riskfree Rate}).$$

The new profit model developed by Rogerson, based on the CAPM, contains the same two profit components identified in equation (3.4) above. The required profit from the pure production contract can now be shown to be the following:

$$\pi^* \text{PPC}(\gamma, \alpha) = \gamma \omega E(c) \quad (3.5)$$

where:

ω = the measure of riskiness or variability of production cost where $\omega = 0$ is no risk and a higher ω equates to a higher risk

Equation, (3.5) represents the total risk multiplied by the share of the risk actually borne by the firm. While there are some similarities between equation (3.5) and (3.2), one now obtains a total measure of risk for production cost, which is then multiplied by the firm's share of the risk. It provides a simpler structure than before by assuming that a single parameter can measure the risk of production cost and that the required profit for bearing risk is proportionate to the share of risk borne by the firm. (Rogerson, 1992, p. XV)

Under the CAPM approach, the expected profit from the pure financing contract is shown to be the following:

$$\pi^*PFC(\gamma, \alpha) = (1-\alpha)(1+\omega)F \quad (3.6)$$

where:

F = the amount of profit the firm would have to be paid if it were risk neutral,

$(1-\alpha)$ = the proportion of financing actually given by the firm,

ω = the measure of riskiness defined above

The above equation, (3.6) is similar to equation (3.3) but includes a factor for total risk for financing. By combining the two previous equations, the following equation is obtained:

$$\pi^*(\gamma, \alpha) = \gamma\omega E(c) + (1-\alpha)(1+\omega)F \quad (3.7)$$

One can then view the above equation as $\gamma\omega E(c)$ equaling profit for the firms share of risk in cost overruns and underruns and $(1-\alpha)(1+\omega)F$ representing profit for the firms contract financing.

To relate equation (3.7) to the CAPM, note that the risk parameter, ω , represents the negative covariance of production costs with the overall stock market. This is a direct result of the assumption of the capital asset pricing model, which is that investors will own a well-diversified portfolio and are concerned only about risk that can't be diversified. The parameter ω captures this element of risk.

E. APPLICATION OF THE CAPM TO THE WEIGHTED GUIDELINES POLICY

The technical risk and contract risk from the weighted guidelines policy can be thought of profit for PPC while profit for working capital can be thought of as PFC. We can now look at the weighted guidelines profit policy through an application of the CAPM.

1. Pure Production Contract Portion

For the PPC part of the contract, we can look at it as two parts. There is a fixed part and a variable part. The fixed part is what all contracts receive, with a normal value being 0.5 percent. The variable part depends on the how much risk the firm bears for cost overruns or underruns. In the above model, γ is the measure of how much risk the firm bears.

The significant difference between the two approaches is that under the present weighted guidelines policy, contract risk and technical risk are calculated separately, and then added together to come up with the total return for risk. However, in a cost plus fixed fee contract, where a firm bears no technical risk, this policy allows for a normal return of 1.7 percent to a maximum of 2.8 percent of expected cost.

The CAPM approach to the weighted guidelines policy corrects the above flaw. If γ is equal to 0, then the firm is not rewarded when it did not bear any risk, no matter what the total value of the technical risk represented by $\omega E(c)$. Therefore the return to risk for the firm is 0.

2. Pure Financing Contract Portion

For the PFC portion of the contract, we can go back to the working capital section of the weighted guidelines policy for equation (1.1) to demonstrate the present profit policy for working capital, which is

$$\pi_{\text{PFC}} = (1-\alpha)R_{\text{TL}}(l)E(c),$$

The CAPM approach to the weighted guidelines profit policy yields the following equation (3.6) for working capital.

$$\pi_{\text{PFC}}(\gamma, \alpha) = (1-\alpha)(1+\omega)F$$

By comparison of the two above equations, we can analyze the return for working capital. The first consideration is the risk premium $(1+\omega)$. This factor is not included in the present policy, but should be. This should be the same risk premium utilized for contract risk.

The second factor for consideration is $(1-\alpha)$ which is included for both equations as it should be. The final factor is what is left over. This provides the following equation.

$$\hat{F} = R_{\text{TL}}(l)E(c) \quad (3.8)$$

The present weighted guidelines formula then calculates the risk-free financing rate as stated above. This however is incorrect from the perspective of CAPM.

The correct formula for the risk-free rate is give by the following formula.

$$F = E(c_t)\{(1 + R_F)^{(l+1-t)} - 1\} \quad (3.9)$$

The formula above takes into account a "time pattern of cost occurrence." (Rogerson, 1992, p. xxii) Thus, it not only takes into account the length of the contract, but also considers whether costs are incurred at the beginning or end of a contract.

F. RECOMMENDED CHANGES

Through the above application of the CAPM to the weighted guidelines profit policy, Rogerson recommends three significant changes to DOD profit policy. First, cost plus fixed fee contracts should no longer be given a return for risk when they do not bear any risk. The present policy of rewarding contractors for risk they do not take on was never intended. Secondly, return for working capital should be increased. The same risk premium utilized for contract risk should be included in calculation on return for working capital. Finally, the risk-free financing rate presently reflects an unrealistic rate. The amount of profit a firm is paid for financing must not only reflect the length of the contract, but also consider whether costs are incurred in the beginning or end of the contract.

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IV. ESTIMATION THEORY

A. BACKGROUND

The previous chapters considered two separate models for profit policy in DOD. The weighted guidelines method is presently being used and determining the effectiveness of this policy has been the subject of many studies with varying results. The traditional approach has been to analyze the weighted guidelines by relying on accounting data for measurement of profits. However the pitfall of this method is that a "normal rate of return for each risk class" must be determined and accounting data is generally not available for each program. An alternative approach is to look at the change in security prices before and after a contract award. The theory behind this approach is the Efficient Market Hypothesis (EMH). The EMH "holds that (1) securities are always in equilibrium and (2) that it is impossible for an investor to consistently beat the market." (Brigham, 1999, p. 352) "A market in which prices always "fully reflect" available information is called efficient." (Fama, 1970, p. 383)

In theory, there are a vast number of professional analysts following a limited number of stocks. As information becomes available about a security, numerous analysts receive that information at about the same time. The value of a security therefore adjusts almost immediately to any new information. Thus, all security price information is embodied in the security price. This lends itself to the

theory that changes in security values represent changes in the value of a firm, which will equal the discounted value of profits.

The application of this theory is the underlying premise of the estimation theory for prize estimation. This approach appears to provide a more accurate and unbiased approach to estimation of prizes. A summary of the model is presented here (Rogerson, 1989, pp. 1284-1305).

B. THE MODEL

The basis behind the model is that multiple defense contractors will work on system design and manufacture prototypes through the concept exploration phase of a program. Full-Scale Engineering Development (FSED) follows this phase. It is during FSED that the government selects a firm or firms to enter into full production of the system. The contract award is generally worth a significant amount to the firm given the large number of systems required, upgrades, spare parts and exports possible.

Given the above competition and prize available, the following model is presented:

$$e_p = V_w + V_L \quad (4.1)$$

where,

e_p = an estimator of the prize or profit

V_w = the change in market value of the winner

V_L = the change in market value of the loser

C. APPLICATION OF THE MODEL

The following is a simplified example of how the estimation theory can be applied (Rogerson, 1997, pp. 93-94). Suppose there is a contract award available worth one billion dollars and there are two contractors competing for the contract. Each firm then has a 50% chance of winning the contract prior to the award date and each will be worth 500 million prior to the announcement of the award. Suppose the first firm wins the competition and the second firm loses. After the announcement of the award, the 1st firm will then be worth 500 million more since the investors know it won the award and the 2nd firm is worth 500 million less since the investors now know it lost the award. This can be summarized as follows:

<u>Firm</u>	<u>Probability</u>
-------------	--------------------

1st Firm	50%
----------	-----

2nd Firm	50%
----------	-----

<u>Stock Market Value Before Announcement</u>	
-----------------------------------------------	--

1st Firm	\$500,000 Million
----------	-------------------

2nd Firm	\$500,000 Million
----------	-------------------

<u>Stock Market Value After Announcement</u>	
----------------------------------------------	--

1st Firm	\$500,000 Million more or \$1 Billion
----------	---------------------------------------

2nd Firm	\$500,000 Million less or \$0
----------	-------------------------------

1\$ Billion = Increase in Winner + Decrease from Loser

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V. DATA COLLECTION AND ANALYSIS

A. OVERVIEW

The missile system contracts selected for analysis are identified in Table 5.1. These systems were previously or are currently utilized by the Department of the Navy and other services. The awards were selected based on availability of data and the requirement that the defense firm be listed on the New York (NYSE), American (AMEX) or National Association of Securities Dealers (NASDAQ) stock exchanges. The contract awards for the Advanced Medium-Range Air-to-Air Missile (AMRAAM) and Hellfire missiles were also selected for analysis but were not included here since Hughes Aircraft was not listed on the stock exchange until 1985 when it was acquired by General Motors.

Table 5.1. Missile System Contracts

Project	Winner(s)	Loser(s)	<i>Wall Street Journal</i> Article date (t=+1)
TOMAHAWK	Hughes	McDonnell Douglas	19 September 1994
HARM	Texas Instruments	General Dynamics, Lockheed	28 May 1974
HARPOON	McDonnell Douglas	General Dynamics	22 June 1971
SPARROW	Raytheon	General Dynamics	13 March 1978

B. METHODOLOGY AND MODEL

The methodology used for analysis of the data is the standard event-study methodology. This type of analysis is widely used in both finance and accounting. (Rogerson, 1989, p. 1298). The determination of abnormal stock returns was estimated with a market model for all firms involved around the event window. Included in this model are dummy variables to designate a particular day within the specified window. The dummy variables take on the value of 1 if the day occurs in the window and 0 otherwise. (Chevalier, 1993) The following equation was utilized:

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 D_{-3} + \beta_3 D_{-2} + \beta_4 D_{-1} + \beta_5 D_0 + \beta_6 D_{+1} + \beta_7 D_{+2} + \varepsilon_i \quad (5.1)$$

where:

Y_i = firm I percentage return on day I,

X_i = S&P 500 percentage return on day I,

$D_{-3} \dots D_{+2}$ are dummy variables which equal 1 if the day occurs in that window, and 0 if otherwise

$\beta_0 \dots \beta_7$ are estimated and ε is the error term. The above equation was estimated for all firms involved using the period of 120 days before the event window and 20 days after the event $[-120, +20]$. By using dummy variables, significant abnormal returns can be identified. The coefficients of the dummy variables for each day represent the difference between the predicted return for that day and the predicted

returns outside the window. T-statistics for the dummy variables are included to identify significant returns given a confidence interval. A t-value greater than approximately 2.0 indicates that the actual returned value in the window is significantly different than the returned value outside the window at the .05 level of statistical significance.

The "event window" is defined as a set of days in which the announcement information for the contract award is incorporated into the stock price. The window of $[-2,3]$ was used for prize estimation in this study based on research by Rogerson that 'two days on either side of days 0 and 1 captures most of the speculative effects in the vicinity of the announcement.' (Rogerson, 1989, p. 1299) Rogerson's research indicates that relative to DOD's announcement procedures, which are to announce awards on day 0 after the market closes, congressmen who had been notified by DOD, had in fact notified other individuals prior to the DOD announcement. Additionally, some congressmen even held press conferences prior to the DOD announcement in order to notify their constituents of the benefits forthcoming from the contract award for their state.

To determine the amount of the prize for each contract award, the cumulative 'abnormal' returns over the event window identified in the model are multiplied by the market value of the firm on day -3. This gives an estimate of the

change in market value for the firm involved. The following sections summarize the analysis conducted for each system.

C. TOMAHAWK SYSTEM

The Tomahawk missile system is a highly advanced missile system utilizing a Terrain Contour Matching and Digital Scene Matching Area Correlation guidance system. It presents a low radar cross-section and carries up to a 1000 lb. warhead payload. The system travels at subsonic speeds and was used extensively during Operation Desert Storm in 1991. Production costs for the system are approximately \$600,000. (U.S. Navy Fact File, World Wide Web, 1999)

The initial contract for Tomahawk missiles called for a contract of \$356 million with later production of \$500 million in missile production. Additionally, further production of an upgraded version was valued at approximately \$1 billion to bring the estimated ultimate value of the contract award to approximately \$2 billion. The analysis of security prices for the Tomahawk missile award are presented for both Hughes, the winner, and McDonnell Douglas, the loser. The regression results that are obtained for the reference timeframe outside the selected window are also indicated.

1. Conclusion

The Tomahawk missile award was a hotly contested contest between Hughes Aircraft Co. and McDonnell Douglas. Initially Hughes approached

McDonnell Douglas with an offer to produce the missile as a joint venture but McDonnell Douglas declined. McDonnell Douglas had also considered selling their missile business prior to the Tomahawk competition but failed to get an acceptable price.

Table 5.2. TOMAHAWK Missile System

	Winner	Reference Regression Equation	Loser	Reference Regression Equation
	Hughes	$(.0004709) + (.893)X$	McDonnell Douglas	$(.0003808) + (.653)X$
Day (-3,+2)	Hughes Abnormal Return	Hughes t-statistic	McDonnell Douglas Abnormal Return	McDonnell Douglas t-statistic
-3	0.02866	*2.02000	0.00219	0.18000
-2	-0.01870	-1.30100	-0.00333	-0.27000
-1	0.01319	0.92500	0.00999	0.81900
0	0.01718	1.21200	-0.01920	-1.58300
+1	-0.00967	-0.66700	0.00673	0.54200
+2	-0.01390	-0.98100	0.00339	0.27900
Cumulative Abnormal Returns	0.01676		-0.00023	
* Significant at the 0.05 level.				

From the analysis, a significant return is seen for Hughes on day -3. Of note also is that on the event day 0, Hughes excess return was positive and McDonnell Douglas had a negative excess return.

The change in market value for Hughes was an increase of \$56,830,629. McDonnell Douglas experienced a change in market value of (\$1,047,231) over the event window, for a total change in market value of \$57,877,860.

D. HARM SYSTEM

The High-Speed Anti-radiation Missile (HARM) system was developed in the early 70s. The HARM system was a versatile missile system that would eventually be used by a wide range of attack and fighter planes for suppression and destruction of enemy radar-directed air-defense systems. The system requires minimum crew input with a smokeless, solid propellant and a dual-thrust rocket motor. This system was used extensively by the Navy and Air Force during Operation Desert Storm. Production costs for the system are approximately \$284,000. (U.S. Navy Fact File, World Wide Web, 1999)

The initial contract was valued at approximately \$40 million. Analysis of security prices is presented for both Texas Instruments, the winner, and General Dynamics/ Lockheed the losers.

Table 5.3. HARM Missile System

	Winner	Reference Regression Equation	Loser	Reference Regression Equation	Loser	Reference Regression Equation
	Texas Instruments	$-(.000566) + (1.337)X$	General Dynamics	$(.0008015) + (1.513)X$	Lockheed	$(.001404) + (1.631)X$
Day (-3,+2)	Texas Instruments Abnormal Return	Texas Instruments t-statistic	General Dynamics Abnormal Return	General Dynamics t-statistic	Lockheed Abnormal Return	Lockheed t-statistic
-3	0.00278	0.13600	0.02838	1.04700	0.01381	0.26600
-2	0.01017	0.50000	-0.01420	-0.52400	-0.00515	-0.09900
-1	0.02403	1.17400	-0.01320	-0.48300	0.00479	0.09200
0	-0.00608	-0.29900	-0.01700	-0.62900	0.03188	0.61500
+1	0.01966	0.96000	0.01948	0.71500	-0.00266	-0.05100
+2	-0.03540	* 1.73800	-0.01020	-0.37700	-0.01150	-0.22200
Cumulative Abnormal Returns	0.01516		-0.00674		0.03117	
* Significant at the 0.10 level.						

1. Conclusion

The data for the HARM system behaved somewhat differently than the other systems. Texas Instruments experienced a negative excess return and Lockheed a positive return on the event day 0. Texas Instruments also experienced a marginally significant negative return on day +2. The Wall Street Journal was

researched in an effort to identify any significant events that would cause the negative excess return, but nothing could be identified.

The increase in market value for Texas instruments over the prize event window was \$36,450,097. The General Dynamics/ Lockheed team experienced a decrease in market value of (\$340,782). The total change in market value was \$36,790,879.

E. HARPOON SYSTEM

The Harpoon missile system was developed to be launched either from surface vessels or from planes and capable of hitting enemy ships from over 50 miles away. The Navy envisioned mounting the missile systems on a wide variety of vessels throughout the Navy. The system also was used extensively during Operation Desert Storm in 1991. Production costs for the system are approximately \$720,000. (U.S. Navy Fact File, World Wide Web, 1999)

Initially the Navy planned to have two contractors develop the Harpoon missile system, however they decided against it after the missile experienced a successful so called launch. The Navy felt the project was no longer 'high risk'.

The initial value of the missile system award was \$60 million with future development and production costs estimated at over \$600 million. Analysis of security prices for the Harpoon system is presented with McDonnell Douglas as the winner and General Dynamics as the loser.

Table 5.4. HARPOON Missile System

	Winner	Reference Regression Equation	Loser	Reference Regression Equation
	McDonnell Douglas	(.002939) +(1.941)X	General Dynamics	(.002523) +(1.716)X
Day (-3,+2)	McDonnell Douglas Abnormal Return	McDonnell Douglas t-statistic	General Dynamics Abnormal Return	General Dynamics t-statistic
-3	-0.01280	-0.53900	-0.00218	-0.09300
-2	0.01626	0.65600	-0.00569	-0.23200
-1	-0.01270	-0.52300	-0.00069	-0.02900
0	0.00981	0.41200	-0.02390	-1.01700
+1	-0.01920	-0.80300	-0.04400	*-1.85700
+2	-0.00178	-0.07500	-0.01690	-0.71700
Cumulative Abnormal Returns	-0.02041		-0.09336	
* Significant at the 0.10 level.				

1. Conclusion

For the Harpoon system, only the excess return on day +1 for General Dynamics was marginally significant at the .01 level. McDonnell Douglas and

General Dynamics experienced positive and negative excess returns respectively on day 0, but not at a significant level.

The market value change for McDonnell Douglas, the winner, was (\$21,008,395). General Dynamics experienced a market value change of (\$29,394,641). Additionally the total abnormal return for General Dynamics was over -9% for the window of [-2,3]. The total market value change was \$8,386,246.

Why McDonnell Douglas experienced a negative change in market value is not readily clear. One possible explanation for this was the news on the contract award day in the Wall Street Journal concerning the project no longer being 'high risk'. This may have triggered investors to now view the project as lower risk and hence lower projected future return.

F. SPARROW SYSTEM

The AIM-7F Sparrow missile system was developed to be deployed on Navy and Air Force fighters. It included advances in the ability to hit targets and easier maintainability. This system was also extensively employed during the Persian Gulf War. Production costs for the system are approximately \$125,000. (U.S. Air Force Fact File, World Wide Web, 1999)

The contract was valued at approximately \$2.3 billion initially. Security price analysis for the Sparrow missile system is presented for Raytheon the winner and General Dynamics, the loser.

Table 5.5. SPARROW Missile System

	Winner	Reference Regression Equation	Loser	Reference Regression Equation
	Raytheon	$(.002194) + (1.822)X$	General Dynamics	$-(.000685) + (1.449)X$
Day (-3,+2)	Raytheon Abnormal Return	Raytheon t-statistic	General Dynamics Abnormal Return	General Dynamics t-statistic
-3	-0.00830	-0.67600	0.03277	*2.45900
-2	-0.00691	-0.56400	0.02346	1.76700
-1	-0.01550	-1.25200	-0.01290	-0.95900
0	0.00390	0.31900	-0.06640	*-4.99990
+1	-0.00332	-0.27000	-0.02450	-1.83700
+2	0.00269	0.22000	0.04533	*3.41300
Cumulative Abnormal Returns	-0.02744		-0.00224	
* Significant at the 0.05 level.				

1. Conclusion

The Sparrow system data presented significant excess returns for General Dynamics on days -3, 0, 1 and 2. However, the abnormal return for +2 was positive which negated almost all of the previous abnormal negative returns.

The market value change for Raytheon was (\$28,843,391). General Dynamics changed by (\$1,009,664). The total market value change was \$27,833,726.

Overall there is no consistent evidence of insiders receiving advance information concerning the systems examined. Hughes Aircraft Company, the winner of the Tomahawk system, did display a significant return on day -3. However, General Dynamics also had a significant return on -3 and they lost the contest for the Sparrow missile system.

VI. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

The purpose of this thesis was to survey current DOD profit policy and consider an alternative economic model for profit policy and calculation of 'prizes' for defense missile contracts. The thesis provided an overview of an economic approach to the weighted guidelines policy using the capital asset pricing model. It also looked at the estimation theory for calculation of contract prizes using four separate defense missile systems. The analysis included estimating predicted returns for the firms involved using a market index, and estimation of prizes for firms involved in the competition. News data was also analyzed to provide background and casual relationships to any abnormality.

B. CONCLUSIONS

Rogerson's application of the CAPM to weighted guidelines policy identifies several deficiencies in the present policy. These include (1) rewarding firms for risk in a cost plus fixed fee contract which was never intended, (2) lower than intended risk premiums for working capital, and (3) an unrealistic risk free financing rate.

The event analysis portion of this thesis suggests that the estimation theory may be applicable to missile defense firms although results overall are

inconclusive. Some of the significant excess returns did not fall within the event window of $[-2,3]$, however this was not abnormal given previous results using the estimation theory. (Rogerson, 1989, p. 1299).

The significance of the prize amounts varied among the systems. The average among all systems was \$32,722,177. Additionally, a negative change in market value for the winner of the Harpoon system was observed. This appears to be attributed to the news released on the day of award announcement that the contract was not high risk.

There does not appear to be any evidence of insider trading or evidence that the market learned of the winner before the announcement date. Significant excess returns prior to the event period were not observed. However, further analysis of a larger number of contests needs to be considered.

C. RECOMMENDATIONS

1. Recommendations for Further Action

It is recommended that further studies be conducted by DOD and academics to assess the current profit policy guidelines utilized within DOD. Alternative profit policies should be considered for implementation.

2. Recommendations for Further Study

It is recommended that the methodology of this thesis be expanded to include a larger group of defense missile systems. Other defense industries could

be analyzed using the same methodology. The results from this thesis could then be compared for consistency with a larger group of firms and contrasted with other defense industries.

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