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INVESTMENT POLICY FOR COST REDUCTION

(LMI Task 76-9)

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FOREWORD

During the period 1967-76, total annual expenditures for military goods (DoD procurements plus Foreign Military Sales) were relatively constant. The value of these procurements in constant dollars, however, declined by approximately 53%. Labor and material costs rose because of inflation and the increasing complexity of weapon systems.

As level defense procurement budgets bought fewer units each year, DoD management increased its efforts to stimulate productivity in defense industry. Recognizing that the rate of investment in plant and equipment is a key element in productivity growth, the DoD sponsored a number of studies related to investment in defense business.

As a result of one, the DoD Profit Policy Study,[1] Defense Procurement Circular (DPC) 76–3, dated 1 September 1976, was issued. DPC 76–3 amended the Weighted Guidelines[2] and directed that a portion of the profit or fee negotiated on a contract be tied directly to capital investment.

Additional changes to procurement policy are necessary to encourage capital investment, particularly for the purpose of cost reduction. The DoD Investment Policy Study (Investment '76), of which this report is a part, represents a step towards that goal. The objective of Investment '76 is to formulate and implement DoD procurement policy that will motivate industry to invest in defense-related, cost-reducing, production facilities.

This report has three parts. Part I contains LMI's findings on three basic issues: what cost-reducing investment opportunities are available to industry?; what would motivate industry to make the investments? and what DoD procurement policy is

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[1] "Profit '76 Summary Report," OASD/Installations and Logistics, 7 December 1976.

[2] Armed Services Procurement Regulation 3–808.

most likely to provide such motivation? Part II presents case studies on the investments made in major production programs. Part III contains appendices produced in the development of Part I.

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PART I. ANALYSIS OF INVESTMENT POLICY

A. OPPORTUNITIES FOR COST-SAVINGS INVESTMENT

Two questions must be answered to provide an adequate context for analyzing industry motivation for investment and for assessing the need for change in DoD policy. Does industry have opportunities for cost-reducing, defense business-related investment? Will industry make the investment if there is adequate return?

To answer these questions, a review of selected industry investment opportunities was conducted.

1. Current And Future Investment Opportunities

The best time for making a cost-saving facility investment for defense production is at the time of tooling for initial production. There are three main reasons. First, the design engineers have the greatest flexibility for selection of manufacturing equipment. Second, once a product design is approved, it tends to become frozen. Third, a design change to an in-production subassembly often affects interfacing subassemblies, necessitating additional redesign and tooling costs.

The F-16 and B-1 aircraft programs are two examples that offer ample opportunities for cost-saving investment. In each case, the prime contractor and the DoD are reviewing the contractors' facility investment plans, analyzing the amount of the contractor's investment and his risk of incomplete recovery. Examples of specific investments on the F-16 program and the magnitude of their potential cost savings are summarized in Table A-1.

Ongoing programs, with planned production schedules extending years into the future, also offer excellent opportunities for cost-saving investment. Examples of investment for the M60 tank, Harpoon Missile, and drone aircraft programs also are shown in Table A–1. The M60 investment will pay for itself if the production program continues

TABLE A-1. EXAMPLES OF COST-SAVING INVESTMENT OPPORTUNITIES

Investment Description	Investment	Annual Operating Cost		Weapon System Benefiting	Estimated Net 5-Yrs. Savings
		Old System	New System		
1. F-16 The Air Force and General Dynamics facility investment plan is designed to meet a 1000+ aircraft buy to be produced in A.F. Plant No. 4. Current equipment represents latest technology available for F-111 program (circa 1967). Two examples of potential net savings to the program are shown.					
a. Profile Mill, 5-Axis, 3-Spindle	$ 1,816,000	Not Provided	Not Provided	F-16	$ 2,824,000
b. 2-Coordinate Measuring Machine	$ 840,000	Not Provided	Not Provided	F-16	$ 1,463,000
2. B-1 The Rockwell International, Inc., North American Division, facility plan covers production of the B-1 in the A.F. Plant at Palmdale, a plant not used in many years. Therefore, this program offers an excellent opportunity for cost-saving investments.					
3. Machine Modernization Tank Road Wheels[1]	$ 426,561	$ 83,104	$ 26,880	M60	$ 281,120
4. Machine Modernization Tank Wear Plates[1]	$ 365,180	$ 203,156	$ 22,444	M60	$ 903,560
5. Automated Turbine Engine Factory[1]	$25,394,705	$15,218,913	$9,145,744	Harpoon, Drones	$30,365,845

[1] "Selected Cases of Capital Investment," Advanced Management Systems, Inc., April 30, 1976.

at a rate of 1200 vehicles per year for about seven and one-half years. However, since the current four machines used for wheel production range in age from 23 to 31 years, the proposed investment might be justified solely on the basis of increased efficiency in the production line.

2. Previous Cost-Saving Investment Opportunities

A review of recent cases of industry investment in cost-saving equipment and facilities confirms that defense industry will invest when capital is available and the anticipated savings are deemed sufficient. Table A-2 summarizes nine cases. Case 1 results in material savings. The next six cases generate savings in both labor and material. The last two reduce labor costs.

The annual savings reported in Table A-2 were those experienced by the companies. The estimated five-year and total net savings are five-year extensions of the annual savings or the extensions of test production lots to total planned production. For the seven investments (excluding Harpoon) with savings computed on an annual basis, a total investment of $5.1 million is anticipated to yield $12.4 million in five-year, pre-tax operating cost savings. The two Harpoon investments with computations on a per unit basis are estimated to yield $285,580 in total pre-tax operating cost savings for a total investment of $24,252.

3. Conclusion

Industry investment data indicate that opportunities for cost-reducing, defense-related facility investment do exist. Industry will take advantage of those opportunities if the return is considered adequate. It follows that any change in DoD policy which enhances the probability of investment recovery or increased return can be expected to generate additional investment.

TABLE A-2. EXAMPLES OF ACTUAL COST-SAVING INVESTMENT[1]

Investment Description	Investment	Annual Operating Cost		Weapon System Benefiting	Estimated Net 5-Yrs. Savings
		Old System	New System		
1. Process for Recycling Flushing Oils	$ 54,595	$ 222,289	$ 18,086	LHA/DD963	$ 1,021,015
2. Metric Thread Cutting Engine Lathe	$ 30,950	$ 18,096	$ 10,267	LHA/DD963	$ 39,840
3. In-Line System for PCBs	$ 39,554	$ 202,852	$ 155,069	ALQ126, SSQ-72	$ 238,915
4. Nutplate Drill Motor	$ 2,322	$ 85,365	$ 3,744	Harpoon	$ 81,621[2]
5. Wire Marker, Cutter, Stripper	$ 21,930	$ 268,896	$ 64,937	Harpoon	$ 203,959[2]
6. Central Storage and Retrieval	$ 600,000	Not Provided	Not Provided	F-14	$ 1,000,000
7. Selected Storage System	$ 175,000	Not Provided	Not Provided	F-15	$ 1,381,100
8. Finishing Facility	$ 2,300,000	Not Provided	Not Provided	F-14	$ 1,675,000
9. Convert Govt.-Owned Profilers from NC to DNC	$ 1,935,049	Not Provided	Not Provided	F-15	$ 7,092,155

[1]"Selected Cases of Capital Investment," Advanced Management Systems, Inc., April 30, 1976

[2]Total program savings.

B. MOTIVATING FACTORS FOR CAPITAL INVESTMENT[1]

DoD's Profit Policy Study culminated in the issuance of DPC 76-3, which rewards a contractor with additional profit or a fee for capital investment on negotiated contracts. DoD recognized that there were limitations to the amount profit could be increased. The question then arose, "What, aside from negotiated profit, would motivate industry to invest for defense business?" The findings of this study with respect to the question are presented in two parts: (1) the general motivating factors for any industrial investment; and (2) the motivating factors that industry indicated would stimulate defense business investment, and that industry would like to see implemented through new or revised DoD policy.

1. General Motivating Factors

The major general motivating factors affecting a company's decision to invest in facilities are:[2]

Expected Net Return: Generally, the expectation of a financial reward is required for a company to take the risk of building a plant or purchasing equipment.

Availability of Funding: A company must be able to finance the investment either from its own funds (internal funds), or from outside sources (external funds).

Cost of Money: A change in the cost of money can make an investment more or less attractive.

Amount of the Capital Investment: If other factors, such as expected revenues, are held constant, an increase in the cost of the capital investment

[1]Sources: "The Defense Industrial Base: Impact of DoD Business Practices," LMI, (to be issued).

"A Guide to the Determinants of Capital Investment," The Conference Board, Spring 1976.

[2]Order of presentation is not meant to signify corporate order of importance. Different motivating factors will influence different types of investments.

will lower the anticipated return, and thereby decrease the desirability of such investment.

Operating Costs: Increases in current operating costs act as an incentive for cost-reducing investment.

Price Inelasticity: The willingness of the marketplace to absorb an increase in a product's price has a favorable effect on net return, and encourages investment.

Production Capacity: The need to increase the level of production may necessitate an increase in the amount of capital investment.

Technology: Technology creates new product possibilities, ideas for cost-saving improvements, and opportunities for increased productivity, all of which generally require investment for implementation.

Government Rules and Requirements: Taxes, depreciation rules, tax credits, safety regulations, pollution control requirements, and procurement policy all affect investment attractiveness.

Competition: Competitors' advances in product, cost, or market share can cause a firm to make an investment.

Demand: Recognition of an opportunity to increase sales for existing products can lead to investment.

2. Defense Business Investment Motivating Factors

During LMI's study of the Defense Industrial Base, companies engaged in producing defense products were surveyed on their motives for investing for defense business. While most of the general motivating factors listed above were identified, two others were singled out as the dominant incentives operating today for defense investment:

Necessity: A company will make that investment necessary to obtain and carry out a contract.

Competition: If a competitor has an advantage, a company will try to offset it—frequently through investment.

When asked to identify DoD policy changes that would encourage investment in defense business, companies suggested:[3]

Elimination of ASPR XV Disallowances: This would allow industry to recover interest costs, all Independent Research and Development (IR&D), and other currently unallowable (or partially unallowable) charges.

Allowance of More Rapid Depreciation: Allowing a more rapid depreciation of facilities would give industry greater assurance of investment recovery on negotiated contracts and thus make investments easier to justify.

Greater Contractor Share of Cost Savings: DoD should allow a contractor to retain a greater share of the savings realized from an investment, and permit the sharing to continue through subsequent contracts.

Termination Protection: The ability to recover the undepreciated portion of program-peculiar assets would reduce risk of incomplete recovery on investments for which the contractor has no alternative use.

Multi-Year Funding with Multi-Year Procurement: If multi-year procurement were accompanied by multi-year funding, companies would be more certain of investment recovery.

The recent promulgation of Defense Procurement Circular (DPC) 76-3 indicates that DoD is serious about encouraging industry to make capital investment. The next step is to institute policy changes that will stimulate cost-reducing investment by allowing greater contractor participation in the savings, reducing the contractor's risk, or by some combination of the two.

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[3]Order of presentation reflects industry's expressed priorities.

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C. DoD POLICY THAT FOSTERS COST-REDUCING INVESTMENT

The preceding sections discussed cost-reducing investment opportunities for firms in the defense sector and motivating factors for capital investment. This section examines existing DoD policy that could be broadened to provide incentives for cost-reducing investment.

Recognizing that:

- The amount of profit that can be paid on a DoD contract is limited by law, and that the recently-issued Defense Procurement Circular 76-3 has gone as far as seems appropriate at this time to induce investment in facilities;
- Defense spending increases of a magnitude that might motivate industry investment are not likely in the foreseeable future; and
- DoD interference in the management/operating decisions of privately-owned firms should be kept to a minimum;

one is attracted first to existing policy—other than profit policy—as a source of ideas for promoting capital investment that would increase productivity.

A review of existing policy was made by the staff of the DoD Investment Policy Study Group (IPSG) and by LMI. Five policy provisions appeared to offer potential for increasing productivity by promoting investment. No one contract should necessarily incorporate all of the following features. Contracting officers should select the combinations that best fit individual contract situations.

1. Termination Protection

Risk of recovery is the greatest deterrent to any investment. To be successful, an investment incentive program must reduce this risk. The obvious solution for defense contracts would be to guarantee that the DoD would buy from contractors–for the unrecovered cost–equipment purchased to improve productivity. Such a guarantee would apply whenever the DoD terminates a contract prior to its scheduled completion, or

significantly reduces the number of units purchased (against which industry would have amortized the investment).

The ASPR should be changed to identify the types of contracts and equipment to which termination protection applies, and to require the following specifications in individual contracts:

- The conditions (contract termination or unit procurement changes) under which such protection applies
- The identification of specific pieces of equipment covered, provided that the contractor can show that they will reduce costs
- An estimate of the cost reduction achievable
- An agreed-upon amortization schedule that will define the DoD's liability for each piece of equipment
- Time limits for the contractors' submission of claims for termination payments and for DoD's settlement
- The assignment of responsibility for removal and disposition
- A provision that sets aside or identifies the funds for termination claims
- The requirement that an assessment be made of the impact of termination protection on the prime contractor's make-or-buy decisions affecting subcontractors
- Flow-down provisions to protect key sub-contractors

2. Multi-Year Procurement

During LMI's study of the Defense Industrial Base, industry indicated that the uncertainty of the market accounted for much of its reluctance to invest for defense production. Most DoD procurements are on an annual basis and are subject to competitive bidding for follow-on procurement. Further, the appropriations for major weapon systems must be approved annually by Congress. Industry thus has the certainty of only a single year's market when assessing the risk of recovering cost-reducing investment.

In certain procurements, the requirement for annual congressional approval would not abrogate the use of a multi-year procurement as an investment incentive. Consumables, such as spare parts, must be procured on a continuing basis and are very seldom, if ever, denied by Congress. Using multi-year procurement, items could be procured under a multi-year Invitation for Bid (IFB) award. This would permit a company to reflect its investment in a lower bid price. Both DoD and industry would benefit—DoD from a lower procurement cost, and industry from a contract of sufficient duration to permit recovery of its investment.

Negotiated contracts for smaller procurements or items not listed as budget line items would similarly benefit. Subcontractors to major weapon system prime contractors would be more inclined to make equipment investments if the market stability of the primes was more certain.

Regardless of a contractor's confidence in the future, his creditors want tangible assurance of repayment. Multi-year contracts will go a long way toward providing such assurance (especially if coupled to termination protection), and should permit industry to secure longer-term loans at more favorable rates.

3. Award Fee

ASPR currently allows the payment of an award fee, as additional profit, if a contractor exceeds stipulated performance goals. The award fee was originally tied to exceeding hardware performance specifications or delivery schedules. In recent years, award fee contracts also have been used to accomodate special situations. Since ASPR does not stipulate the performance criteria to qualify a contractor for receipt of an award fee, the fee could be used to encourage cost-reducing investment. For example, the contractor could be required to develop a sound capital investment program, and the award fee could be adjusted, on a quarterly basis, to reflect implementation of the program.

While the award fee concept and DPC 76-3 may appear quite similar, there is one important difference. DPC 76-3 is designed to be used when a new contract is being

negotiated, and reflects past investment decisions. An award fee could be used in conjunction with DPC 76-3 to focus on investment made after a contract is awarded.

4. Shared Savings

In the commercial marketplace, the greatest incentives for cost-reducing investment are: reduction of operating costs, increase in internal cash flow, and addition to company profits. These incentives are greatly diminished in the defense marketplace due to the Government's practice of pricing and repricing. While DoD would like to be the sole beneficiary of cost-savings from capital investments, it could motivate industry to make a greater investment in facilities if it adopted a mutually beneficial shared-savings policy. Such a shared-savings program should:

- Guarantee a minimum number of years or procured units for the sharing (A three-to-five-year period is suggested)
- Apply to investments that could not be made prior to the start of work on the contract
- Provide sufficient flexibility in establishing the share line
- Require written approval of the investment by the contracting officer
- Not be limited to the instant contract
- Not be considered as contract profit for purpose of renegotiation

5. Rapid Depreciation

Depreciation is defined in ASPR 15-205.9(a) as:

> ...a charge to current operations which distributes the cost of a tangible capital asset, less estimated residual value, over the estimated useful life of the asset in a systematic and logical manner.

This is the accounting definition of depreciation, which pertains to historical cost, and has no reference to any replacement cost of the asset. Normal depreciation is an allowable element of contract cost, provided the contractor follows acceptable depreciation policies and procedures.

Section B stated that defense contractors consider the rapid depreciation of capital assets crucial to their investment decisions. All firms, especially defense contractors, are interested in recovering their capital investment as rapidly as possible.

Cost Accounting Standard (CAS) 409 requires a contractor to depreciate assets over the documented useful life (the period of time he has historically kept similar equipment) or economic life (that period of time for which he foresees a use for the equipment). Economic life of equipment, which may be shorter than physical life or IRS class life, terminates when there is no longer an opportunity for its use.

To take advantage of the flexibility of CAS 409, DoD procurement personnel have interpreted CAS 409 to permit industry to depreciate an investment over its economic life. This interpretation will permit the use of a more rapid depreciation schedule. At present, certain provisions under Certificates of Necessity[1] permit the depreciation of emergency facilities over a five-year period. If CAS 409 and Certificates of Necessity were applied more broadly, the average depreciable life of assets would be reduced, and investment would thereby be further encouraged.

[1] ASPR 15-205.9(3).

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D. ADDITIONS TO DOD POLICY TO MOTIVATE COST-REDUCING INVESTMENT

Additions to policy could be made that would increase industry's incentive to make cost-reducing investment. Since new policy may require congressional action, the items discussed below should be considered as candidates for future implementation.

1. Funding of Multi-Year Procurement (MYP)

Under the present MYP procedure of ASPR 1-322, funding is in accordance with the program year for which each quantity is authorized. If Congress were willing to appropriate multi-year funds for MYPs, contract quantities could be funded for the entire production period.

Fully funded MYPs would reduce the present uncertainty about cancellation. Long-term contracts would allow contractors (and subcontractors) to plan and schedule their production processes more efficiently. Even if cost-reducing investment was not stimulated, funded MYPs should result in lower-cost DoD procurements because they would generate increased contractor competition and lower contractor costs.

The use of funded MYPs should stimulate investment for the following reasons:

- Long-term capital would be more easily obtainable.
- Firms could consider alternative methods for producing the product because of the longer-term contracts. Under present year-to-year contracts, an investment in specialized automated equipment that entailed a one-year lag between ordering and installation would probably be too risky, even though cost savings could justify its purchase.
- Firms would be assured recovery of more of their invested capital.

In general, the use of funded MYPs should stimulate investment by defense contractors. The level of stimulation could be augmented by the use of other motivators (e.g., rapid depreciation, increased sharing rates, economic price adjustment, etc.).

2. Economic Price Adjustment (EPA) of Depreciation Costs

The preceding section identified depreciation as a means of recapturing the initial cost of a capital asset. If the asset is depreciated over a period of high inflation, the accumulated depreciation will be much less than the reacquisition cost of the asset.[1] The most commonly used type of EPA is the Cost Index Method of ASPR 3-404.3(c) (3). The indices used are often industry-specific, and are generally based upon material and labor indices published by the U.S. Department of Labor, Bureau of Labor Statistics. As constructed, the EPA indices do not account for the effect of inflation on depreciation costs. Since data on actual inflation and net book value of equipment are readily available, EPA indices could be broadened to measure the impact of inflation on depreciation.

Another approach is to base the depreciation charges on the replacement value of the asset. The replacement value of the asset could be adjusted to reflect the reduced efficiency of the actual asset compared to an equivalent replacement. This method is used by the West German Government, as described in Sections 37 through 42 of Regulation PR/NO 30/53 on Pricing in Public Contracts, November 1961 and December 1967.[2]

Depreciation based upon replacement value would encourage investment, but it might encounter some problems:

- Congress would have to change the tax laws.
- Determining the replacement value of an existing asset is very difficult; equipment does deteriorate physically and can become technically obsolete.

The preferred approach (with a higher likelihood of implementation) would be to employ the EPA clause of ASPR to provide protection against the effect of abnormal inflation on depreciation costs.

[1] Depreciation is an allowable cost, but it is paid in historical dollars. Other allowable costs are paid in current dollars.

[2] See Appendix B of Heiss, K. D., Vol. I.

3. Revolving Capital Fund

It has been suggested that the DoD establish a revolving capital fund to finance investment in capital equipment—both Government-owned and contractor-owned. The fund would serve as a standby line of credit. The initial assets of the fund could consist of existing Government-owned facilities (GOF) and an appropriation from the Congress. Replenishment could come from the sale and rental of GOF, interest and principal payments (or surrogates) from contractors, yearly appropriations from Congress, and a portion of the administrative charges on foreign military sales.

The potential beneficial aspects of a DoD revolving capital fund are:

- The current two-to-three year lead time between the time of GOF project approval and the release of funds would be substantially reduced.
- DoD personnel could select, procure, and make available high-technology GOF that contractors might have overlooked.
- The leasing of GOF would reduce some of the uncertainty confronting DoD contractors. If the contract were terminated, the contractor would not have to worry about the capital recovery of the investment.
- Contractors unable or unwilling to acquire funds from commercial capital sources could use the revolving fund for cost-reducing investment.
- The cost of the capital obtained from the revolving fund should be less than from commercial sources. The lower capital cost would reduce the internal rate of return (IRR) cutoff level, and allow contractors to justify additional cost-reducing investment.
- The availability of the revolving fund might interest more firms in defense business.

The potential negative aspects of the revolving capital fund are:

- DoD's policy is to rely primarily on free market forces to achieve the efficient allocation of resources in defense procurement.

- In providing loans or GOF to contractors, the DoD would be competing with commercial sources of capital.
- The DoD has forecasted a reduction in the level of GOF for the current Five Year Defense Plan. The revolving capital fund would probably increase the availability of GOF and perpetuate its use.
- The decisions of industry and the revolving fund's management concerning cost-reducing investments would not be subjected to the checks and balances inherent in the acquisition of capital from commercial sources.
- Capital for establishing the fund would probably come out of the DoD's budget, and might divert funds from more essential requirements.

Although a few contractor/contract situations may require the DoD to supply either funds or GOF, a revolving capital fund is not believed to be a viable method for increasing investment in cost-reducing assets. Implementation of the investment incentives discussed in Sections C and D should preclude the need for a revolving capital fund.

E. SUMMARY AND RECOMMENDATIONS

1. Summary

For the most part, contractors now invest in defense business either to gain contracts or to satisfy contractual obligations. Investment for the purpose of cost reduction apparently is hampered by some DoD procurement policies, procedures and practices.

Investment incentives to ameliorate this situation are summarized in Table E–1. They are grouped into two categories. The first contains incentives already in the ASPR, which appear to require only broader application or minor change for immediate effect. The second comprises incentives that require substantial change in the ASPR, or congressional action, before they can be implemented.

The potential of each incentive depicted in Table E–1 is LMI's subjective evaluation. The elements of the cost reduction column are estimates of the likelihood that the incentives (applied singly) will cause defense contractors to invest in cost-reducing capital assets. For example, Shared Savings (the ASPR Value Engineering clause, with modification) could provide contractors with a major share of the cost-savings generated by an investment and hence could be a strong incentive.

The "Potential For Implementation" column presents LMI's estimates of how quickly and easily the incentives can be implemented. The Rapid Depreciation technique, for instance, is already on the books (CAS 409), and therefore receives a high rating. The Shared Savings (Value Engineering clause) is in the ASPR, but would have to be more specifically tailored to cost-saving investment; it is therefore given a medium implementation rating.

2. Recommendations

The following recommended investment incentives for DoD cost reduction

require different levels of effort and periods of time to implement, but they can be addressed simultaneously:

- Initiate the ASPR changes necessary to broaden the termination protection provided a defense contractor for cost-reducing investment.
- Insert a new "Shared Savings" clause into the ASPR, or revise ASPR 1-1701, "Value Engineering," to effect a broader shared-savings program.
- Issue directives calling for more extensive use of multi-year procurement and award fees.
- Employ CAS 409 and Certificates of Necessity to provide more rapid depreciation.

The DoD should explore with the Congress the advisability of fully funding multi-year procurements. While such funding may not be practical across-the-board, it could be worthwhile on a product or project basis.

The use of industry material-specific economic price adjustment indices should be further studied. Much DoD procurement requires exotic materials and advanced manufacturing equipment. Industry-wide inflation factors are sometimes inadequate. For example, use of such a factor for the steel industry may not totally compensate the manufacturer of rolled homogeneous armor used in the production of tanks.

Until the effects of the above recommended policy changes become known, the issue of establishing a revolving fund to finance contractor investment in modern production equipment should be deferred.

TABLE E-1. SUMMARY OF INVESTMENT INCENTIVES

	References[1]	Potential For Cost Reduction	Potential For Implementation	Remarks
Changes in Policy				
1. Shared Savings	ASPR XVII	HIGH	MEDIUM	Sharing Rate and Period Should be Stipulated
2. Rapid Depreciation	ASPR 15-205.9 CAS 409	HIGH	MEDIUM	Requires Interpretation of CAS 409 or Congressional Action
3. Award Fee	ASPR 3-405.5	MEDIUM	HIGH	Can be used in Conjunction with Defense Procurement Circular 76-3
4. Termination Protection	ASPR VIII	MEDIUM	MEDIUM	Time Lag; Requires Broader Interpretation of, or change in, ASPR
5. Multi-Year Procurement	ASPR 1-322	MEDIUM	MEDIUM	Removes some Uncertainty; Limited to Certain Contract Types
Additions to Policy				
1. Full Funding of Multi-Year Procurement	--	HIGH	LOW	Requires Congressional Action
2. Economic Price Adjustment of Depreciation Cost	ASPR 3-404.3(c)	MEDIUM	HIGH	Requires Interpretation of, or change in, ASPR
3. Revolving Capital Fund	--	MEDIUM	LOW	Requires Congressional Action

[1] References are not exhaustive.

PART II

INVESTMENT CASE STUDIES

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PART II. INVESTMENT CASE STUDIES

INTRODUCTION

In May 1975, the Deputy Secretary of Defense established the Defense Profit Policy Study Group (Profit '76) to revise DoD profit policy so that contractors would be encouraged to make capital investments that would reduce the cost of weapons systems and materiel. The recognition that profit was not the only consideration involved in defense contractors' capital investment decisions led to the chartering of the Investment Policy Study Group. The purpose of this group was to improve DoD's ability to deal with non-profit-related factors influencing contractors' capital investment decisions. The principal methodology of Profit '76 is quantitative in nature; i.e., collection and analysis of comparative data from the defense and commercial sectors. However, we also believe that the contractor's perception of defense procurement influences his response to Government needs as much as do Government regulations. We therefore concluded that it was worthwhile to look behind the statistics and determine how current DoD procurement policy influenced corporate decisions.

Detailed studies were performed of selected programs within four aerospace companies, as follows:

- The Boeing Company - 747 Program
- McDonnell-Douglas Corporation - Harpoon and F-15 Programs
- General Dynamics Corporation - F-16 Facility Plan
- Bell Helicopter Company.

We expected such case studies to offer insights into the contractors' views of the relative risks and rewards of commercial and defense opportunities.

The case studies were organized around four general topics: capital investment decisions, contractual relationships, financing, and market projections. This arrangement

was modified for the General Dynamics case, which covers capital investment only. The Bell Helicopter case contains an analysis of three growth periods in Bell's history in addition to sections on investment and market projections. This case offers a view of corporate decisions made in the light of market demand.

Corporate vice-presidents, controllers, and their staffs were interviewed to obtain data and the corporate point of view concerning the problems associated with defense contracting. Aerospace companies were selected because they are major recipients of defense procurement dollars.

Probably the most interesting finding that emerged from our case studies was that there appeared to be very few direct cost reduction incentives in Government contracts, other than those associated with the survival of the firm. Any financial benefits generated by the contractor's cost-reducing investments will flow to the Government, because of the cost-based nature of Government contracting. Reduction in costs generally translates into a reduction in price to the Government and a reduction in sales for the company. (Unit buys are dictated more by requirements than by unit costs.) Stated differently, discretionary or marginal capital investment must be justified on the basis of the survival of the total program. These marginal investment decisions will therefore depend upon long-range predictions that are often uncertain and thus dictate the adoption of a particularly conservative investment program. The Government is therefore usually deprived of the benefits of cost-reducing marginal capital investments.

This same conclusion was also arrived at in LMI's recent study of the defense industrial base. Necessity and competition were identified as the primary motivators of defense-oriented companies. See Part I, Section B of this report for a more detailed discussion of capital investment motivators.

A. THE BOEING COMPANY- 747 PROGRAM[1]

1. Introduction

The Boeing 747, the largest airplane ever built for commercial service, was conceived in the early 1960's. Boeing market research indicated that an airplane of its size would be required to meet the growth in airline passenger and cargo traffic predicted for the 1970's and 1980's. The 747 reached formal project status in March 1966, when Boeing's Board of Directors decided to proceed with the program on a tentative basis, subject to review and firm approval at a later date. On August 13, 1966, Pan American Airways, Inc., signed a contract with Boeing for purchase of 25 such aircraft, to be delivered between September 1969 and August 1970, and an option on 10 more for later delivery. In the five months following March 1966, $1.8 billion in airline orders for the super-jets were received, one of the largest pre-production orders in commercial airplane history.

The program schedule for the 747 is depicted in Figure A-1. Table A-1 gives the program chronology. Table A-2 gives the current status of the program, while Table A–3 gives the sales figures for the 747 program.

2. Special Customer-Related Problems

To introduce the 747 to the market successfully, Boeing had to solve a number of customer-related problems. The problems were not as publicized as technological ones, but their solutions were critical to the success of a profitable program.

(a) Customer Financing

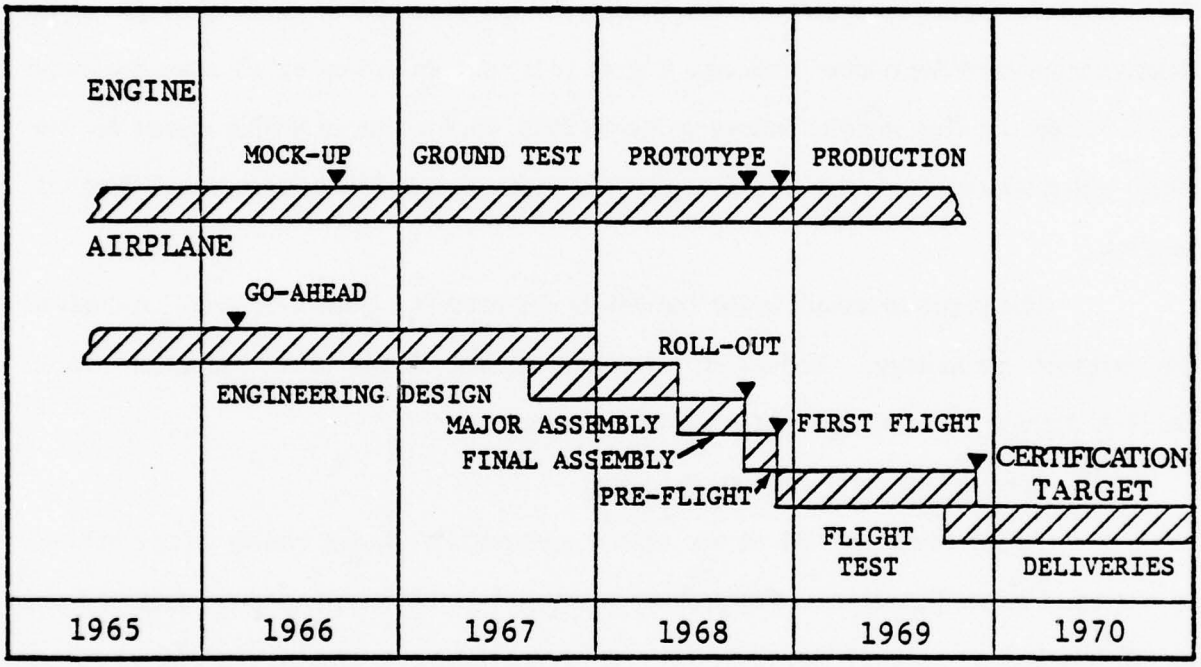
The magnitude of the 747 program required unusual financing arrangements. In 1966, the 747 cost about three times as much as the 707, and about four times

[1]The Boeing Company is hereafter referred to as "Boeing." Information on program history taken from Boeing Public Relations Release S–1667, July 1975. Unless otherwise noted, all financial data have been obtained from the open literature or as a result of the author's estimates. Boeing neither denies nor confirms the accuracy of such data.

as much as the 727. This cost, coupled with the increased rate of customer progress payments required by Boeing, placed a heavy financial burden on airlines during a period of decreasing yield. Although Boeing had no direct responsibility to secure financing for its customers, it had to take into account the airlines' financial situation in making its own financial investment plans.

FIGURE A-1. 747 PROGRAM SCHEDULE

(November 1967)



Source: The Boeing Company

(b) Airports

The increased size of the 747 and its anticipated passenger loads created the following airport-related problems:[2]

- New hangers had to be built and more land had to be found at crowded main-line airports.

[2]Watkins, H. D., "747 to Intensify Airport Space Problems," Aviation Week and Space Technology, Nov. 20, 1967, pp. 49-59.

TABLE A-1. 747 PROGRAM CHRONOLOGY

Spring 1963	-	Engineering group is organized to plan an airplane which will meet passenger and cargo growth predicted for the 1970's.
March 1966	-	Boeing Board of Directors decides to proceed on 747 program, subject to review and firm approval at a later date.
April 1966	-	Pan American World Airways announces it will purchase 27 Boeing 747s.
June 1966	-	780 acres are acquired adjacent to Paine Field, Everett, Washington for 747 manufacturing plant.
September 1966	-	Airline orders for new superjet reach value of $1.8 billion.
January 1967	-	Production operations for 747 begin at the Everett plant.
May 1, 1967	-	Everett assembly building – world's largest – is activated.
Late 1967	-	First nose section arrives at Everett plant from Wichita Division; components manufactured by major subcontractors begin arriving.
Mid-June 1968	-	JT9D test engine is flown by Pratt & Whitney.
September 30, 1968	-	First 747 is completed.
November 1968	-	Boeing announces a longer-range 747, capable of greater payloads, to be designated 747B. Freighter and convertible versions are also to be offered.
February 9, 1969	-	Initial flight of first 747 is completed. Flight test program begins.
December 30, 1969	-	Boeing 747 is certified by FAA for commercial passenger service.
January 21, 1970	-	Boeing 747 commercial service on New York – London route is begun by Pan American World Airways.

TABLE A-2. 747 PROGRAM: STATUS AS OF 9/18/75

Number of customers	42
Airplanes sold	300
Production rate	2/month

TABLE A-3. 747 SALES
(Millions)

1969	$ 81
1970	1,908
1971	1,532
1972	711
1973	767
1974	594

- Concourse space to handle 747 loads would have to be three times that necessary to handle 707 loads.
- Baggage handling had to be improved. At program go-ahead, the goal was to develop a long-range system that could sort and process 500 pieces of luggage a minute. The best handling system at that time could handle 70 bags a minute.
- Ground height of the aircraft passenger door sills varied between 15 ft. and 17 ft., rendering existing passenger-loading equipment inadequate.
- At least 11 airports throughout the world had one or more underpasses at runway or taxi-strip points that required strengthening to support the weight of the 747.

Boeing felt some responsibility for solving the problems surrounding the long-range impact of airport congestion and inconvenience on the growth of air travel. One of the steps the company took in 1966 was to send its manager of airport requirements to every major airport in the United States, Europe, Austrialia, and the Orient expected to serve the 747. Boeing also distributed a brochure titled "Boeing 747 at the Airport," consisting of drawings showing various characteristics of the aircraft relative to airport activities. It was updated every five months and had a distribution of 1200.

(c) Flight Crew Training

The 747 program called for new approaches to training flight crews. Because of a shortage of instructors, Boeing had to spend $12 million on training its own. Simulators and visual displays were devised for training purposes, since the cost per hour of flight time for the 747 was nearly prohibitive. As demand for training services increased, Boeing expanded its training operations; each new aircraft now purchased now includes a basic training package.

3. Capital Investment

To introduce a new generation of commercial aircraft successfully, the manufacturer must structure the production schedule to the special demands of the airline industry. When a new aircraft model is offered that provides worthwhile improvements in flight operations or customer satisfaction, most airlines want to start flying it as soon as possible, so that no single airline is able to gain a marketing advantage. The advent of the jet transport and the jumbo jet were marked by the same phenomenon: massive initial orders from the airlines, as they all tried to put the new equipment into service at the earliest possible date. As a result of market demand, a manufacturer must be able to deliver relatively large numbers of aircraft early in the production cycle.

Capital investment for the 747 was tailored for an expected initial inflow of orders, followed by a decrease to a level representing replacement orders, small lots from new customers, and orders for derivation models. At peak capacity, the Everett

Washington plant can produce 8 to 10 747s a month; it is believed capable of operating at a profit at a rate of 1.5/month after the initial order surge. The sales history of the program (Table A–3) shows that the expected sales profile (but not magnitude) occurred, with peak production of eight aircraft per month and a present rate of about two per month. Because of severe world economic conditions, total sales will not meet the initial Boeing planning figures of 450 747s in operation by 1976. By mid-1976, a total of about 320 747s will have been produced.

The need for an initial large production capacity necessitated a large investment in fixed assets. Before delivery began, Boeing and its subcontractors were estimated to have had a cash investment in the 747 program of more than $1.5 billion in development, tooling, facilities, and manufacturing start–up. This is the largest sum risked to date by private companies in a commercial airplane program. Of this amount, Boeing's cash investment reached a maximum of $700–$800 million just before the first delivery in late 1969.

The 747 program represented a departure from past practices. Major subcontractors invested considerable sums, and agreed, in the early, high-risk stage of the program, to defer recovery of their own non-recurring development costs, thereby gambling with Boeing on the commercial success of the 747. Although this approach had been used to a degree in previous U. S. commercial programs, like the Douglas DC–9, the magnitude of the 747 risk-sharing eclipsed previous efforts. Deferred amortization schedules were individually negotiated with major suppliers upon a minimum base of 200 airplanes.

(a) Boeing's Investment

A measure of the level of activity associated with the 747 program in the three and one-half year development-to-delivery cycle is Boeing's construction of two facilities, totaling 5,500,000 sq. ft. of floor space, each initially occupied a year after ground was broken. From 1966 to 1969, the prime investment period for the 747, Boeing

invested more than $740 million in new plants and equipment. While some of these facilities also serve Boeing's other product lines, the investment surge did correspond to the 747 development cycle, as can be seen from Table A-4. In its 1966 Prospectus for the 5 1/2% Debentures, the company suggested that the total nonrecurring costs of the 747 model series could reach $500 million or more.

TABLE A-4. NEW ADDITIONS TO PLANTS
(Millions)

Year	New Additions to Plants
1964	$ 33.6
1965	67.8
1966	294.6
1967	246.5
1968	120.2
1969	86.9
1970	21.3
1971	6.4

Note: 1966-69 was the prime investment period for the 747.

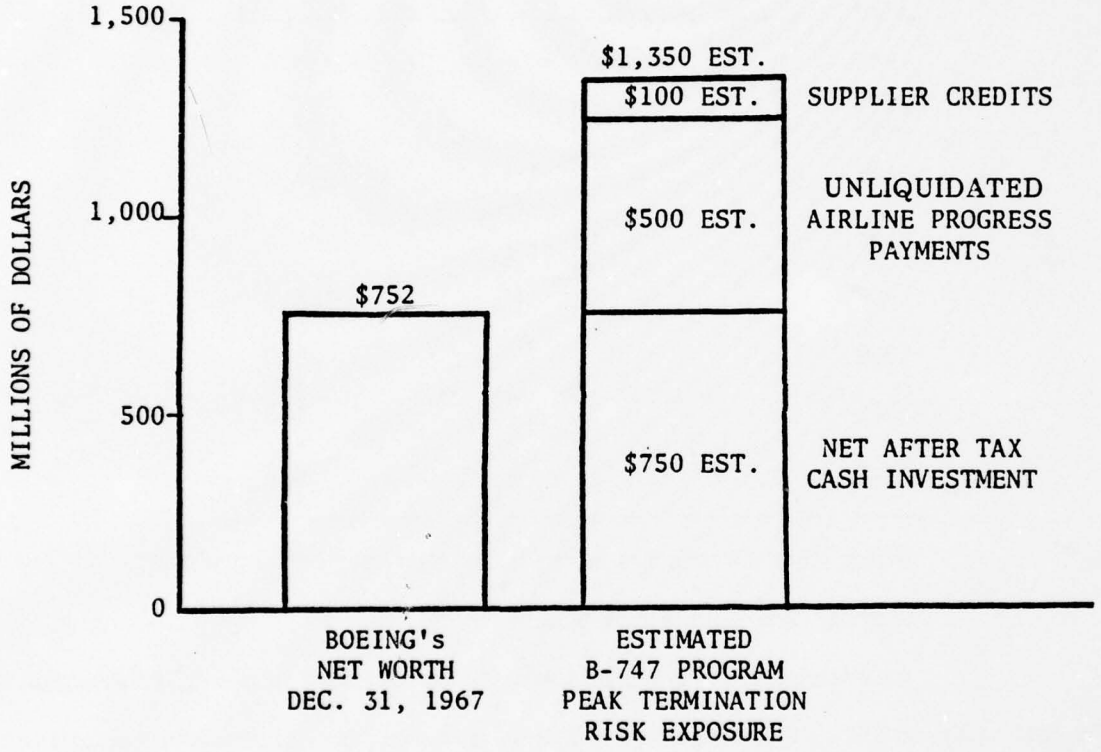
Source: The Boeing Company.

As noted earlier, Boeing's peak cash investment in the B-747 program has been estimated at $700 million to $800 million. However, Mr. Richardson has estimated that allowance for contingent repayment obligations, unliquidated airline progress payments and supplier commitments would result in a total risk exposure to Boeing substantially larger than its peak cash investment in the program.[3] Some idea of the

[3]Richardson, Lemont K., "Financing and Risk Sharing in Commercial Airplane Programs," Financial Analysts Journal, May-June, 1969, p. 44.

absolute and relative magnitude of Boeing's estimated peak termination risk exposure in the 747 program can be obtained from Figure A–2. The magnitude of the risk is even more apparent if one compares the amounts at risk to the company's net worth. These 1969 estimates of risk and cash requirements are consistent with Boeing's subsequent financing arrangements, as shown in Section 4, "Financing."

FIGURE A-2. BOEING'S ESTIMATED PEAK TERMINATION RISK EXPOSURE IN THE 747 PROGRAM



Source: Richardson, op. cit., p. 44

Boeing's investment in capital assets was concentrated at three locations:

(1) The Everett Facility

The Everett Facility is located on 780 acres of land adjacent to Paine Field in Everett, Washington, 30 miles north of Seattle. The $200 million complex

includes what was, and might still be, the largest single plant in the world: a 3,500,000 sq. ft. assembly building with twin 1100 by 300 ft. final assembly bays. Located elsewhere on the site are warehouses, a service building, three office buildings and a cafeteria. A paint hangar and field-support building are located on the preflight apron adjoining the field. The site is served by a three-mile railroad spur, built to bring in construction steel for the buildings, and production parts and subassemblies for the 747s.

(2) The Auburn Facility

This new facility at Auburn, Washington (about 20 miles south of Seattle) serves as a central fabrication plant for all Boeing manufacturing. Its construction was prompted by the 747 program and began in February 1966.

The concentration of most of Boeing's manufacturing activities at Auburn permitted volume installation and heavy use of high-cost equipment that would otherwise have been economically unfeasible. Among the specialized units at Auburn are:

- Numerically-controlled milling and profiling machine tools with a 110 ft. bed length
- Compound-curvature wing skin panel-stretching and creep-forming jigs with preset temperature control
- Some of the world's largest autoclaves, 50 ft. by 24 ft. internal dimensions, for heat-and-pressure curing of bonded structures
- Chemical-treatment tanks, whose elongation to handle parts in the 747 and beyond size category alone cost $3 million.

(3) Wichita Facility

Wichita is responsible for the fabrication of the nose section of the 747, and various doors and access panels. The nose section is divided into nine major pieces and shipped to Everett in special rail cars. Capital investment in special tooling for the production of these parts is estimated at about $5 million, with another $12 million invested in working capital.

As a result of investments in plants and equipment during the 747 program, Boeing doubled its total plant square footage to more than 24 million sq. ft. Figure A–3 is a running total of the covered floor area by ownership for the company. The total covered area listed as Government-owned is primarily at Wichita and Ogden. These plants are old and highly depreciated. Over the last ten years or so, Boeing's plants have gone from 50% company-owned to more than 75% company-owned, with the bulk of company-owned plants being newer facilities.

(b) Subcontractor Investments

In order to round out the capital investment picture for the 747, a brief look at subcontractor investment is appropriate.

(1) Northrop-Norair

Norair is designing and manufacturing the 747's 153 ft. long passenger compartment. Gross cash investment in the program was about $230 million. The major new facility needed for the 747 program was a $10 million, 504,000 sq. ft. part and tool assembly building. In addition, a $800,000 facility extension has been added at Northrop's Ventura Division to permit production of the 747 wing fairings.

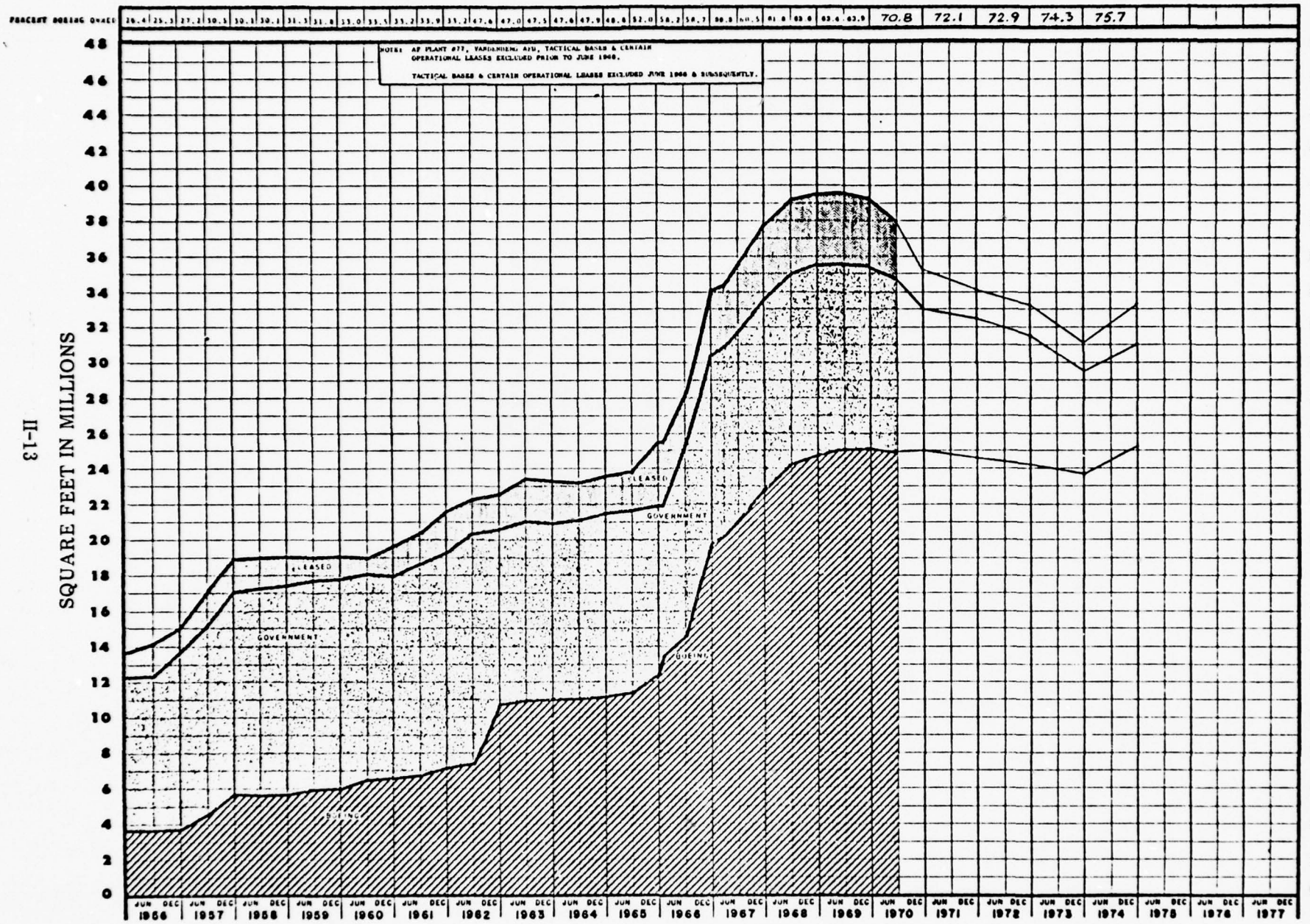
(2) Fairchild Hiller Corporation

The firm, which designs and produces some wing control surfaces, made a substantial investment in design efforts and facilities expansion. At its peak, the engineering effort at the firm's Republic Division involved about 200 engineers and extended over about 18 months. These expenses were originally capitalized over a 200 aircraft base.

(3) Rohr Corporation

Rohr designs and manufactures engine nacelles and struts. While the company did not separate out its 747 investment, it obtained $30 million in long-term financing in 1966, as part of a general expansion to handle the 747, C5A, Douglas and Grumman programs. During 1968 and 1969, Rohr is estimated to have spent about $14 million in facilities and equipment alone.

FIGURE A-3. COVERED FLOOR AREA BY OWNERSHIP - TOTAL COMPANY



SOURCE: The Boeing Company

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(4) LTV-Vought Aeronautics Division

The firm is responsible for the design and manufacture of a fuselage section and the empennage of the 747. It has invested about $18 million in new equipment and facilities.

4. Financing

The enormous capital requirements of the 747 program made it necessary for Boeing to tap a wide range of capital sources.

(a) Capital Markets

All facets of the capital markets were utilized during 1966.

- Senior Securities: In August 1966, Boeing issued a prospectus for $130 million of 5 1/2% Convertible Subordinated Debentures due 1991. The issue was successful. In 1967, the issue was called for conversion into stock at a profit to the holder. In 1966, Boeing also arranged for the private placement of $175 million of 6 3/8% notes with 22 lenders.
- Equity: During 1966, Boeing sold $112 million of capital stock to the public.
- Revolving Bank Credit: A total of $401 million in revolving bank credit was arranged during 1966. The $827 million total of this package is a good indication of the 747 program's cash requirements. The short-term financing requirements grew from $400 million in 1966, to more than $900 million between 1970 and 1972. The short-term financing arrangements for 1966 to 1974 are shown in Table A–5.

(b) Supplier Credit

On previous aircraft programs, the prime manufacturers assumed most of the financial risk and supplied a significant portion of the financing. Subcontractor and supplier firms absorbed part of the working capital requirements through supplier credits

TABLE A-5. RECENT SHORT-TERM FINANCING ARRANGEMENTS

	Yr. End 1966	Yr. End 1967	June 1969	Aug 1969	Nov 1969	Mar 1970	Feb 1971	Feb 1972	Oct 1972	Feb 1973	June 1973	Jan 1974	Apr 1974
1966 Revolving Credit	$200												
1967 Revolving Credit		$200	$200	$209	$209	$209	$209	$146	$100				
1972 Revolving Credit								$409	409	$300	$300	$200	$200
2nd Bank Credit		300	200	209	209	209	209						
3rd Bank Credit					150								
4th Bank Credit						200	200						
BFC Bank Notes			250	262	254	171	184	262	260	225	175	175	50
BFC Lease Participation						144	132	119	111	107	102		
Open Lines	201												
	$401	$500	$650	$680	$822	$933	$934	$936	$880	$632	$577	$375	$250

Source: The Boeing Company

or delayed payment arrangements, but did not underwrite any of the financing risks. No matter what happened to the prime (short of bankruptcy), they could expect payment in full for their work. The escalating financing requirements of the wide-body jets required a new approach to financial participation by the subcontractors and suppliers.

Not only did Boeing ask its suppliers to undertake a considerable amount of design work, but Boeing's major 747 subcontractors also provided financing at risk. This risk-sharing aspect of the 747 effort has probably established a trend for future large aircraft programs, in the opinions of both Boeing officials and its major subcontractors. Although the major subcontractors eventually accepted the idea of risk-sharing with the prime manufacturers on the 747 program, they were not too eager when Boeing first presented them with the concept. In the November 20, 1967 issue of Aviation Week, E. H. Boullioun, then a Vice President of the Commercial Airplane Division, said that all of the potential major subcontractors expressed initial resistance to the idea and several turned down the bid to participate: "They didn't have the money and didn't know where to get it."[4]

The risk-sharing agreements between Boeing and its major subcontractors vary considerably. In general, the major subcontractors were expected to recover their non-recurring costs over the first 200 aircraft. The average price for the first 200 units so negotiated was expected to be reached around the 114th or 115th aircraft. In late spring of 1968, however, Boeing took steps to relieve its major suppliers of their deferred risk positions. By then, Boeing had firm orders for 150 aircraft and options on 25 more, and was confident enough of breaking even to relieve its suppliers of some of the financial risks.

In addition to amortizing their non-recurring costs over a 200-aircraft lot with no guarantee that sales would reach that level, the suppliers also furnished credit to Boeing through their progress payment provision with the company. Boeing paid the

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[4]O'Lone, Richard G., "Subcontractor Role Grows in 747 Work," Aviation Week and Space Technology, Nov. 20, 1967.

suppliers progress payments on a schedule roughly coincident with the flow of airline progress payments to Boeing. Boeing's final payment, however, was deferred until the airplane had been fully paid for and delivered to the airline customer. This deferred payment lag averaged about six to eight months for most suppliers. Mr. Richardson estimated total supplier credit on the 747 program at about $100 million.

(c) Customer Credit

Airlines help finance the working capital requirements of commercial airplane makers through advance payments and progress payments. Prior to the wide-body jet era, airlines would make a 2% or 3% down payment upon signing a firm order, followed by progress payments that paid the manufacturer between 25% and 30% of the total price about six months prior to delivery. The balance was paid in full upon delivery.

At the beginning of the 747 program, it is believed that contractors were asked to make progress payments amounting to about 50% of the fly-away price six months prior to delivery. Present progress payment rates for the 747 have apparently now been brought more in line with past rates, as Figure A–3 seems to indicate. Figure A–4 represents the advance payment and progress payment schedules for commercial and military 747 sales.

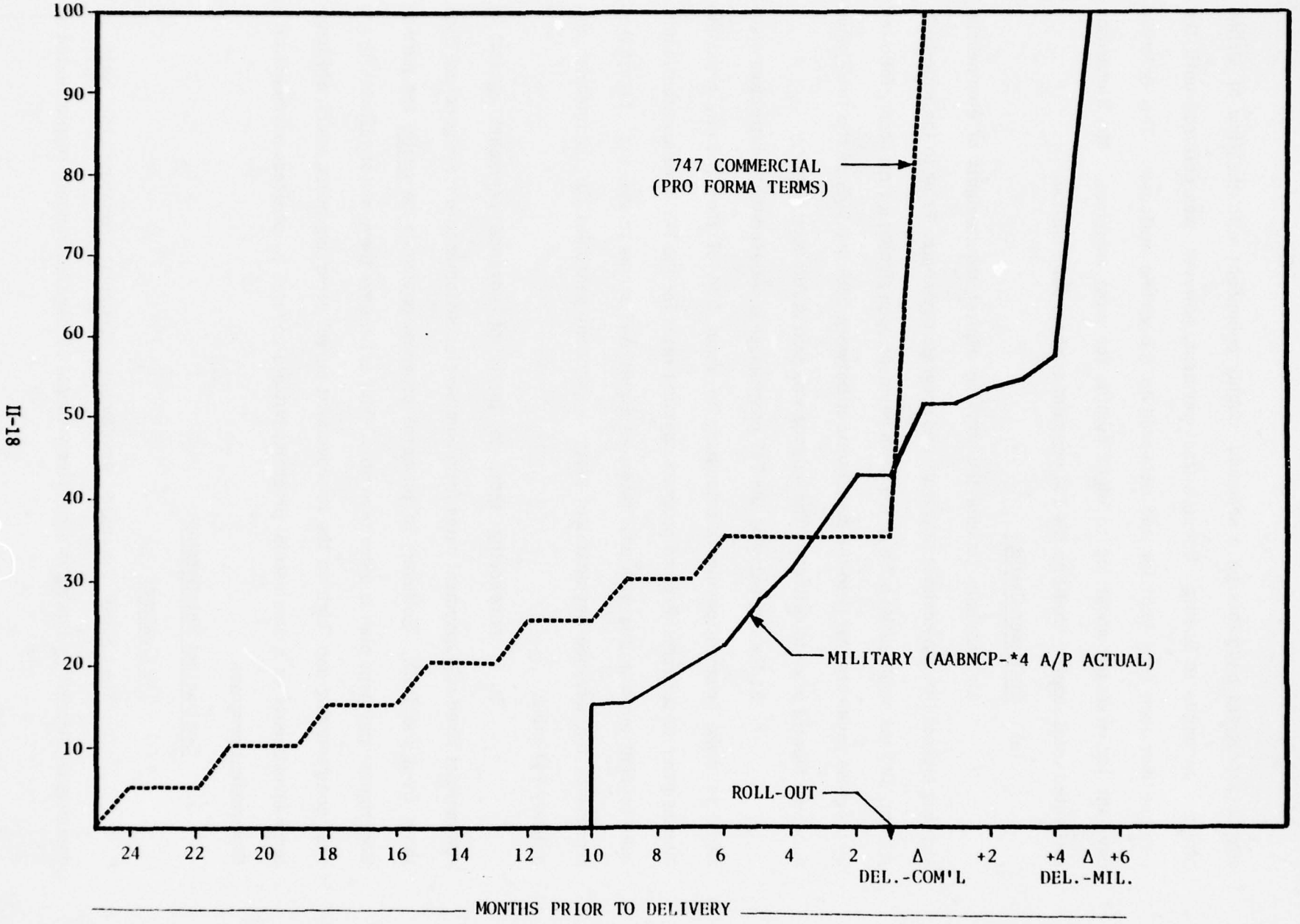
It is noteworthy that, in terms of advance payments against a commercial fixed sale, payment rates from commercial customers are more generous than those from the DoD. However, in terms of progress payments on costs, the normal Government payment plan is more favorable. This is because there are significant "front end" non-recurring and "high on the improvement curve" recurring costs, which are long-term investments on a commercial program, but are covered by progress payments on a Government program.

5. Contractual Relationship

(a) The Contract

The basic Purchase Agreement document covering the sale of commercial aircraft by Boeing is a relatively simple 20-page instrument, supplemented by

FIGURE A-4. ADVANCED AND PROGRESS PAYMENT SCHEDULES - COMMERCIAL AND MILITARY 747 SALES



about 50 pages of exhibits covering product assurance, customer support and price adjustment clauses. In still another section are the aircraft configuration data. The total thickness of the document is measured in inches, whereas the sales of 747's to the Government (the AABNCP) required a contract the thickness of which was measured in feet.

Some key clauses of the Boeing standard commercial contract are described below:

- Escalation: The contract contains escalation clauses to adjust the prices of the airframe and the engines for inflation. Both escalation formulas use Bureau of Labor Statistics Indices to correct the base price of the items for the effect of inflation.
- Termination: Clauses setting forth the obligations of both parties in the event of termination for a number of controllable and uncontrollable causes are contained in the Purchase Agreement.
- Payments: The contract contains a payment schedule (both advance and progress payments) for each individual sale. These terms are described in greater detail in Section 3, "Financing."

(b) Comparison of Government and Commerical Procurement Based on the 747 Major Subcontract Procurements

This section contains a Boeing summary outline of the processes involved in major systems procurement. Government prime and major subcontract procurement requires more time, personnel, and data than 747 major subcontract procurement of equivalent dollar, technical and work content.

Procurement processes and business principles are basically the same for DoD/NASA prime contracting and industry major subcontracting, both military and commercial. Both the Government and industry:

- Establish a requirement for the system or subsystem to be procured.
- Obtain prior funding commitments.

- Develop work statements and procurement performance specifications.
- Prepare RFP packages and schedule total source selection processes.
- Establish selection criteria. Set up source selection boards and review teams and obtain legal reviews at specific points in the selection process.
- Recommend and obtain management approval of sources selected.

As a result of this procurement process, both Government and industry try to select a source that will furnish a product that meets or exceeds performance requirements, and can be delivered on schedule at a realistic price.

Generally, the industry procurement system is more flexible. For example, the time from issuance of a RFP to final source selection can more easily be shortened to fit into the demands of a rigidly scheduled program like that of the 747. Because of this flexibility and speed (more so in commercial subcontracting than in military subcontracting), industry can operate more economically.

The Government prime selection process averages 25 – 50 weeks, while the selection process for the 747 major subcontractors took 12 weeks. (See Table A–6.) The 747 major subcontract program is a good example of industry's ability to organize the procurement process with minimal secondary constraints and inhibitions (such as geopolitical considerations). The availability of resources, the readiness to do the job, the reliability of the subcontractors' commitments and the tradeoff of risks and benefits entailed in the final selection were the only considerations necessary.

Even though Government and commercial procurement systems are basically similar, there are areas of significant difference other than the source selection process time. These are: terms and conditions, make or buy considerations, changes, bid solicitation, data requirements and source evaluation. (See Tables A–7 through A–12.)

TABLE A-6. SOURCE SELECTION PROCESS TIME

Government		Industry (747)	
Establishment of Bidders' List	3 - 4 weeks	In-House Screening of Sources	3 weeks
RFP Issuance to Bid Submittals	6 - 8 weeks	Invitation to Bid to Bid Submittal	3 weeks
Source Selection	8 - 12 weeks	Source Selections	1 week
Management Approvals (up through Secretary of Defense)	4 - 20 weeks	Management Approval (Master Plan Committee)	1 week
Negotiation	4 - 6 weeks	Negotiation	4 weeks
Total	25 - 50 weeks		12 weeks

Source: The Boeing Company

6. Market Projections

Boeing's experts have reportedly forecast that airline traffic will average 6% to 7% growth between now and 1985, less than the 15% of the 1960's, but much better than 1975's 2.4%, and they are roughly in line with other independent estimates. If this prediction holds true, Boeing reckons that $48 billion (at 1975 prices) will be spent by western airlines over the decade. By far the biggest share of this total will be $24 billion for up to 500 medium-range aircraft of the 727-300 type, with more sales to follow after 1985.[5] Having had 52% of western jet transport sales between 1958 and 1974, Boeing obviously expects to capture a large share of that $48 billion market predicted for the decade.

Although there seems to be agreement on the traffic growth rate, there is much less agreement on how it will translate into new equipment purchases by the airlines. An Econ Inc. study for NASA estimates that only $500 - $700 million annually

[5] "Big Brother Boeing," The Economist, July 26, 1975, p. 70.

TABLE A-7. TERMS AND CONDITIONS

Government	Commercial
Quite often major programs include some terms and conditions that are not strictly necessary, some that are novel or experimental and some that incorporate proposal documents, management systems and other ancillary matters. Much of this material appears to be included on the premise that the contract should not omit any of the elements that went into the selection process. Boeing has identified a basic set of Government terms and conditions in which there are a total of 161 clauses. (Circa 1972 - the number is, of course, greater each year.) On the SRAM Program, 101* of these 161 basic clauses were utilized, and 9 additional clauses were negotiated. In addition, 52 special schedule provisions were negotiated. Thus, on SRAM, there are 162 clauses in the terms and conditions (Contract -0876). On Government subcontracts, terms and conditions, including prime flow down, are fewer than on prime contracts but still numerous. For example, on the SRAM Program, an average of 85 clauses were negotiated for each of the RFI major subcontracts.	On 747 subcontracts, terms and conditions were limited to 32 clauses plus a special pricing agreement.

*"A" Series - 42
"B" Series - 59
101

Source: The Boeing Company

TABLE A-8. MAKE OR BUY CONSIDERATIONS

Government	Commercial
Detailed make or buy substantiation is required. It is difficult for the prime to enter a new product area, particularly if the development of a similar product has been supported by the Government, or a requested make item is a new product for the prime. Lengthy negotiations are normally required. The process may be subject to unilateral direction from the Government.	On the 747, Boeing was free to make internal decisions rapidly, based on: - Limiting own investments. - Subcontracting the maximum number of major items. - Obtaining maximum subcontractor financial participation. - Obtaining maximum risk participation. - Securing engineering support. - Obtaining facilities and manpower commitments.
TOOLING	
The prime requires extensive computer listings to be submitted to the Government. These are physically audited by the Government. On Government subcontracts, the supplier submits a computer listing for Boeing and/or Government physical audit.	On commercial subcontracts, the subcontractor submits a verified computer listing.
APPROVALS	
On major prime programs, the sequence is through a number of echelons, quite often up to the Service Secretaries and the Secretary of Defense.	On the 747, due to the financial arrangements and cost impact on the program, approvals went to top management. This involved three levels of management.
Final decisions may take one to five months, in some cases up to eight months.	Final decisions averaged one week.

Source: The Boeing Company

TABLE A-9. CHANGES

Government	Commercial
Class I	Class I (Master Changes)
Changes must be submitted in specific formats. An average of 45 days is required to prepare request and 21 weeks to negotiate and obtain approvals.	On commercial programs (747), Master Changes can be negotiated and implemented from a minimum of one day to an average of eight weeks.
Procurement Specifications:	Procurement Specifications:
It is difficult for the contractor to convince the Government that certain changes are in the interest of the Government, even when supported by a cost - technical trade.	On commercial programs, specifications can be changed unilaterally (performance, weight, envelope size, etc.), as long as there are no impacts on commitments to the customer.

Source: The Boeing Company

TABLE A-10. BID SOLICITATION

Government	Commercial
Competitive bids for almost all procurements are required. They are either: Advertised - Publicized in Commerce Business Daily. Negotiated - Solicited from the maximum number of qualified sources. Any firm can request and receive a bid if it was not on the original bid list.	Bids are not advertised on commercial programs. Bid lists consist of selected competent sources, based on past performance, financial capabilities, technical expertise, quality, etc. On 747, for example Boeing: - Screened 23 companies. - Selected 14 companies for preliminary negotiations. These were companies that were known sources. Boeing had confidence based on prior performance. This type of bid solicitation allows closer rapport with the prospective subcontractors, and reduces to a great degree the cost and formalities of competition prevalent in Government prime contracting. The key points considered during the preliminary negotiations of two to three weeks were: - Financial capability - Quality and Quantity of Technical Personnel - Facilities Commitment - Profit Percentage - Deferred Payments As a result of these preliminary negotiations, seven companies were selected and letter contracts negotiated for the major airframe sections.
On Government programs, Boeing is often required to submit bid lists and source selections to the contracting officer for approval. These approvals are time-consuming and can take from three to six weeks.	On commercial programs, bid lists are normally approved at the manager level. Source selections are approved at the Director and Division Manager level. The process normally requires less than one week.

Source: The Boeing Company

TABLE A-11. DATA REQUIREMENTS

Government	Commercial
Data requirements vary considerably, depending on the agency and type of program.	Data required from the subcontractor are kept to the minimum necessary to monitor progress.
On major military programs, there are a large number of reports required during the contract life. These reports are quite often very detailed and obviously costly.	On the 747 Program, monthly subcontractor reports were: - During Letter Contract - 35 - During FPI Contract - 10 - During FP Contract - None*
For example, on the SRAM Program, Boeing supplied during the DDT&E contract 353 separate line item reports. The total is now down to 300 for production.	*It should be noted that for those subcontractors with design responsibilities two reports are still being received on an as-required basis. These are the specification control document report (SCD) and the part identification number report (PIN). In addition, engineering stress/fatigue type data is furnished as required.
From the start of program on 11-1-66, Boeing will have submitted a total of 14,344 separate reports.	The original 747 reports consisted of cost, tooling, design, production control quality, etc. type of reports.
A typical example of a recurring report is the CSCS (Cost Schedule Control System Criteria). This report is keyed into the applicable WBS (Work Breakdown Structure).	Reports such as CSCS (Cost Schedule Control System Criteria) are not used commercially because of the cost of collecting the necessary data.

Source: The Boeing Company

TABLE A-12. SOURCE EVALUATION

Government

Evaluation Board

Approximately 125 - 150 people are required for each prime evaluation.

Proposals

The typical proposal submitted consists of 60 - 70 documents:

- Management Proposal

  Summary of overall approach to accomplishing the job.

- Program Plans

  Can consist of up to 34 separate plans covering schedule, reliability, quality control, configuration management, manufacturing, etc.

- Statement of Work

- Technical Proposal Package

  Normally consists of six to ten plans, such as summary description, system description, hardware design descriptions, operational services, etc.

- Specification packages of 18 - 20 system and subsystem specifications.

- Cost proposal package

  Consists of cost proposal and backup documentation.

Commercial

Evaluation Board (747)

Seven people are required for each major subcontract, and a total of 50 for all seven major subcontracts.

Proposals

747 proposals for the letter contract consisted of one document covering:

- Commitment to make major investments in facilities.
- Extent of participation in program financing and risk, including deferred payments.
- Capability to assign sizable engineering group to program immediately.
- Acceptance of design responsibility.
- Maximum profit plan commensurate with financial risk.
- Amortization plan for amortizing N/R engineering, tool engineering and tooling costs over 200 airplane program.
- Abbreviated Statement of Work.

Additional 747 proposal documents received for the FPI subcontracts were:

- Complete Statement of Work.
- Cost proposal including back-up documentation.
- Schedule Plan.

Source: The Boeing Company

will be available from domestic airline internal funds for long-term aircraft investments.[6] Allowing a generous margin for financial leverage and for foreign airline purchases, one might put the funds available for new aircraft purchases at about $2 billion a year for the next five to ten years. Another study performed by Stanford Research Institute (SRI) for FEA's Office of Economic Impact suggests that the depressed state of the industry makes any significant purchases of new aircraft unlikely until 1977 or 1978; these purchases will be mainly for existing or derivative aircraft. Even into the 1980's, according to SRI, purchases are likely to be in smaller lots than in the 1950's and 1960's, and the previous pattern of massive fleet replacements may be a thing of the past.[7]

Although the dimensions of the potential market are debatable, the consensus is that the airline industry is in no condition to bear the cost of a new generation of airliner. The Wall Street Journal of September 24, 1975 reported that the financial community was increasingly dubious about its desire or ability to maintain its support of the industry. Banks and insurance companies have over $14 billion invested in air transportation, accounting for about two-thirds of airline indebtedness. One insurance company executive warned:

> There isn't any question that there is a growing group within our ranks that's all in favor of pulling the plug on the next airline that comes along needing another bailout from us to carry it through a crisis. . . . We're getting tired of carrying the industry while watching the outlook for our loans growing more and more uncertain.[8]

Even if the financial community doesn't let a carrier go under, it clearly has lost its appetite for helping airlines raise the necessary capital to upgrade essential equipment. "Due to poor earnings performance and future uncertainties, the public markets appear closed to new airline securities for the foreseeable future," said

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[6]"Changes Brewing in Aircraft Financing," Aviation Week and Space Technology, Nov. 10, 1975, p. 111.

[7]"Study Sees Airline Industry Realignment," Aviation Week and Space Technology, Nov. 10, 1975, p. 25.

[8]Fandell, Todd E., "Airline Industry Lenders Grow More Doubtful That They Should and Can Continue Support," WSJ, Sept. 24, 1975.

Frederick W. Bradley, Jr., vice president of First National City Bank of New York. He added that institutional lenders haven't indicated any interest in extending long-term loans to the industry and many banks are much less interested in airline loans than in the past.[9] Poor economic conditions and pessimistic traffic outlook also figured in United Airlines' indefinite deferral of a decision on the Boeing 727-300, which finally resulted in Boeing's decision not to produce that aircraft.

Boeing's next generation of airliner, the 7X7, which could be produced in the early 1980's, must face these realities. Boeing is trying to put together a production consortium allowing a significant percentage of the aircraft to be produced in foreign countries. Cooperation with Japan and Europe would help Boeing raise the $1 billion or so risk capital needed to launch the program. Since the Japan/Europe investment would almost certainly come from Government sources, however carefully disguised, it would imply (though not guarantee) that the national airlines of the countries involved would buy the result.

Commercial markets for the next five years or so therefore appear uncertain, with little prospect for the introduction of a new-generation airliner before the early 1980's. Cautious Boeing Commercial Airplane Co. sales estimates for 1976 would seem to bear out this trend. The 30% of Boeing's sales to DoD offer a better prospect, as far as availability of funds is concerned. Programs like the aerial tanker and the AMST present Boeing with good sales opportunities and, in the case of the AMST, the possibility of derivative commercial sales. To better pursue these military markets, Boeing established a new organization, called the Boeing Military Airplane Development Organization, to tap the company's widespread aircraft technology resources and apply them to expanding its military aircraft business.

Under the present commercial market conditions, military markets are an important source of sales for Boeing, and are likely to remain so. As a Boeing executive

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[9] Fandell, op. cit.

pointed out, Boeing is so suited to large technical systems that it will always be a Government contractor.

B. McDONNELL DOUGLAS CORPORATION - HARPOON AND F-15 PROGRAMS

1. Introduction

McDonnell Douglas Corporation (MDC) was formed by the merger of McDonnell Company and Douglas Aircraft Company, Inc. in April 1967. Its major current programs include: production of DC-9 and DC-10 commercial jet aircraft; production of the F-4 Phantom and A-4 Skyhawk military combat aircraft; development and production of the F-15 Eagle air superiority fighter aircraft; development and production of a number of space vehicles, missiles and other aerospace products, including the Harpoon anti-ship missile and the Dragon anti-tank weapons system; and the development of the Advanced Medium STOL Transport. McDonnell Douglas' commercial customers include many of the world's air carriers. Military aircraft and missiles are produced for the U. S. Air Force, Navy and Marine Corps and foreign governments. Spacecraft and launch vehicles are produced for the Air Force and NASA.

Aerospace was MDC's only line of business that, for the five years ended 31 December 1974, contributed 10% or more of sales or earnings before income taxes. Sales by classes of similar products for the last five years are as described in Table B–1.

The breakdown of sales for 1970-1974 among U. S. commercial sales, foreign commercial sales (including sales to commercial airlines owned by foreign governments), U. S. Government sales (including those for foreign government use), and foreign government sales (primarily of military and space products) is depicted in Table B-2. The performance of the company over the five years ending 31 December 1974 is described in Table B–3.

The remainder of this section treats aspects of capital investment, financing, contractual relationships, and market projections for MDC as a whole. Sections 2 and 3 describe the Navy Harpoon anti-ship missile and the F-15 Eagle tactical military aircraft programs. These programs are representative modern weapons programs, sufficiently advanced in their life cycles to furnish reasonable data of the type desired.

TABLE B-1. SALES BY CLASSES OF PRODUCTS

	1970	1971	1972	1973	1974
		(In Millions of Dollars)			
Sales:					
Commercial Aircraft	$ 592	$ 590	$1,113	$1,298	$1,338
Military Aircraft	853	813	876	1,016	1,145
Spacecraft and Missiles	465	494	571	536	429
Automation, Electronics, and Optics	178	172	166	153	163
Total Sales	$2,088	$2,069	$2,726	$3,003	$3,075
Percentage of Total Sales:					
Commercial Aircraft	28.4%	28.5%	40.9%	43.2%	43.5%
Military Aircraft	40.8	39.3	32.1	33.8	37.2
Spacecraft and Missiles	22.3	23.9	20.9	17.9	14.0
Automation, Electronics, and Optics	8.5	8.3	6.1	5.1	5.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: McDonnell Douglas Corporation, Form 10-K, 1974

(a) Capital Investment

Capital investment requests at the working level are reviewed at succeeding managerial levels. Requests that survive this process are sent to corporate headquarters, where a staff vice president for properties and facilities conducts a further review. The capital expenditure requests that eventually reach corporate-level decision-makers are detailed documents. Several pages of text, usually accompanied by a cost analysis showing savings from the proposed expenditures, are not uncommon, even for expenditures of less than $50,000. Expenditures may also be justified by the requirements of certain contracts. Such options as continued use of existing equipment or obtaining the desired equipment from other parts of the corporation are also usually discussed. A ranking of incentives for capital investment at MDC would be: first, the requirement to keep current in technology, and second, the requirement to reduce costs to remain competitive on old programs permitting competitive bids on new programs.

TABLE B-2. SALES BY CUSTOMER

	1970	1971	1972	1973	1974
		(In Millions of Dollars)			
Sales					
Commercial Sales:					
United States	$ 166	$ 342	$ 846	$ 750	$ 485
Foreign	482	302	325	621	939
Total Commercial	$ 648	$ 644	$1,171	$1,371	$1,424
Government Sales:					
United States	$1,412	$1,386	$1,517	$1,604	$1,586
Foreign	28	39	38	28	65
Total Government	$1,440	$1,425	$1,555	$1,632	$1,651
Total Sales	$2,088	$2,069	$2,726	$3,003	$3,075
Percentage of Total Sales:					
Commercial Sales:					
United States	8.0%	16.5%	31.0%	25.0%	15.8%
Foreign	23.0	14.6	12.0	20.7	30.5
Total Commercial	31.0%	31.1%	43.0%	45.7%	46.3%
Government Sales:					
United States	67.6%	67.0%	55.6%	53.4%	51.6%
Foreign	1.4	1.9	1.4	.9	2.1
Total Government	69.0%	68.9%	57.0%	54.3%	53.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: McDonnell Douglas Corporation, Form 10-K, 1974

(b) Financing

McDonnell Douglas' approach to capital investment is to commit what is necessary to maintain its business base. Since 1970, the capitalization of the company has increased by about $450 million, of which about $376 million was provided by internal sources.

Working capital is provided through the classical routes of progress payments and lines of credit. No data were available to permit estimating the amount of

TABLE B-3. CONSOLIDATED SUMMARY OF OPERATIONS
Five Years Ending 31 December 1974
(In Thousands of Dollars, Except Per Share Data)

	1970	1971	1972	1973	1974
Sales	$2,088,180	$2,069,061	$2,725,684	$3,002,626	$3,075,036
Cost of Products and Services	1,613,211	1,644,597	2,165,639	2,389,063	2,480,828
Research and Development[1]	275,834	204,194	147,491	142,824	139,460
Interest and Debt Expense	13,592	17,208	28,762	25,174	50,602
Income Taxes (Credits)	(2,947)	14,461	83,133	97,115	70,585
Net Earnings	5,474	20,386	97,635	133,311	106,684
Earnings Per Share	.19	.57	2.47	3.36	2.77
Dividends Declared Per Share	.30	.31	.32	.38	.40

[1]In accordance with the Financial Accounting Standards Board Statement No. 2, issued in October 1974, the above summary for years 1970-1973, inclusive, has been restated to reflect all research and development as expensed when incurred.

Source: McDonnell Douglas Corporation, Form 10-K, 1974

working capital as a fraction of total sales dollars necessary to finance defense business. MDC, however, like other defense contractors we interviewed, considers earnings part of the source of funds required to meet total working capital requirements.

(c) Contractual Relationships

Details of the contracts for the Harpoon and F-15 programs are contained in Sections 2 and 3. An interesting aspect of DoD contracts raised by MDC personnel was the risks associated with being a supplier to the Government:

- Existence of a Program: Until the award in June 1971, MDC had spent approximately $6.5 million on the Harpoon Missile Program

without any guarantee that it would ever get a contract, or even that there would be a program. These expenditures represented a commitment of managerial and engineering facilities and capital resources. If the Government had not pursued the Harpoon program, these resources would have been wasted. Worse, these expenditures would represent resources that should have been applied elsewhere to ensure the survival of the firm. The Harpoon program was eventually initiated and MDC won the contract, but in commercial markets, such large investment in competitive "winner take all" programs seldom occurs.

- Termination: Termination clauses leave MDC without a guarantee that current contracts will be completed. MDC has been involved in the MOL, SPARTAN and Gemini B programs, all of which the Government terminated.
- Second Sourcing: Second sourcing takes potential sales away from the contractor. Dragon is an example of an MDC program that is subject to second sourcing.
- Break-Out: The Government has the option of "breaking-out" a segment of a program and furnishing that equipment GFE. This further reduces the contractor's total sales volume.

(d) Market Projection

About 40% of total MDC sales are commercial aircraft. As explained in the Boeing case study, the market for commercial airliners over the next five years is uncertain. Still, MDC is presently engaged in a number of major DoD programs that can be expected to produce sales well into the 1980's. The combination of the F-15 and F-18 allows the company to compete in both the sophisticated and lightweight tactical aircraft markets. Missile programs such as Dragon and Harpoon will yield solid sales for some

years to come and furnish MDC with a good base for other missile configurations. While the majority of MDC sales in the near future will be to DoD, a major effort is underway to add sales and earnings by external and internal diversification, and thereby reduce undesirable reliance on Government business.

2. Harpoon Missile Program

MDC initiated a survey and analysis of Navy weapon system requirements in early 1964. These studies led the company to stress system and technology analysis and associated conceptual work, which concentrated on the anti-ship mission.

MDC used Independent Research and Development (IR&D) funds in the mid-1960's to study tactical missiles in relation to Navy needs, and established contacts with NAVAIR[1] and NWC,[2] identifying areas of interest versus MDC capabilities. In late 1964, a NAVWEPS[3] report signified interest in an air-surface missile capable of being launched from ASW[4] aircraft against ship targets. The MDC study group turned its efforts in this direction, concentrating on the guidance and propulsion aspects. By mid-1965, the Navy developed a tentative specific operational requirement (TSOR) and tested the S-2E aircraft with an AS-12 missile. The Gulf of Tonkin incident, involving use of missile-equipped Komar Patrol Boats against U. S. destroyers, pointed out the extreme need for the Anti-Ship Missile (ASM) studies. By mid-1967, the IR&D effort had produced reports on the system study and missile guidance problems, particularly the problem of homing on maneuvering surface targets.

The MDC Florida facility participated in a cooperative R&D study of the ASW/ASM problem during mid-1967. The group began working with subsystem

[1]Naval Air Systems Command

[2]Naval Weapons Center

[3]Naval Weapons System Command

[4]Anti-Submarine Warfare

subcontractors, investigating and evaluating key technology and actual hardware. In late 1967, a six volume report was produced, firmly identifying the threat, guidance, warhead, and configuration of a missile capable of countering it. The study also included detailed cost effectiveness and fleet integration information.

Having expended $2.5 million prior to Navy contract definition action in 1968, MDC continued the study effort, refining the missile weapon system and verifying subsystems. The work continued through 1971, resulting in numerous MDC/subcontractor tests and reports that refined the technology and design requirements for the ASM weapon system. The Harpoon Request for Proposal (RFP) was issued on 22 January 1971. MDC's competitors were: General Dynamics/Boeing, Hughes, Raytheon, and North American. Negotiations were conducted with General Dynamics/Boeing and MDC in May 1971. MDC was awarded a contract in June 1971.

(a) Investments

MDAC-East used company funding for the Harpoon program, beginning in the mid-1960's. Four types of investments were made.

(1) IR&D and B&P Expenditures

IR&D and Bid and Proposal (B&P) represent legitimate overhead costs associated with the production of Government-oriented goods. MDC views expenditure of any resource as an investment in its appropriate segment of the market; the IR&D and B&P funds expended in the Harpoon program, therefore, are considered by MDC to represent an investment in the program.

Table B-4 shows the amount of funds MDC has expended over the 12-year life-to-date of the Harpoon program. It should be noted that until the award in June 1971, MDC had spent approximately $6.5 million on the Harpoon Missile Program, with no guarantee of ever getting a contract. In fact, prior to RFP release in January 1971, there was no assurance that there would be a Harpoon program.

TABLE B-4. MDC INVESTMENT IN HARPOON
(Millions)

CY	Expenditures
1964	$ .090
1965	.143
1966	.025
1967	.682
1968	1.376
1969	1.856
1970	1.415
1971 Thru Award	.911
Subtotal at Award	$ 6.498
1971 After Award	$ .912
1972	.955
1973	1.345
1974	1.707
1975	1.260
Subtotal After Award	$ 6.179
Total	$12.677

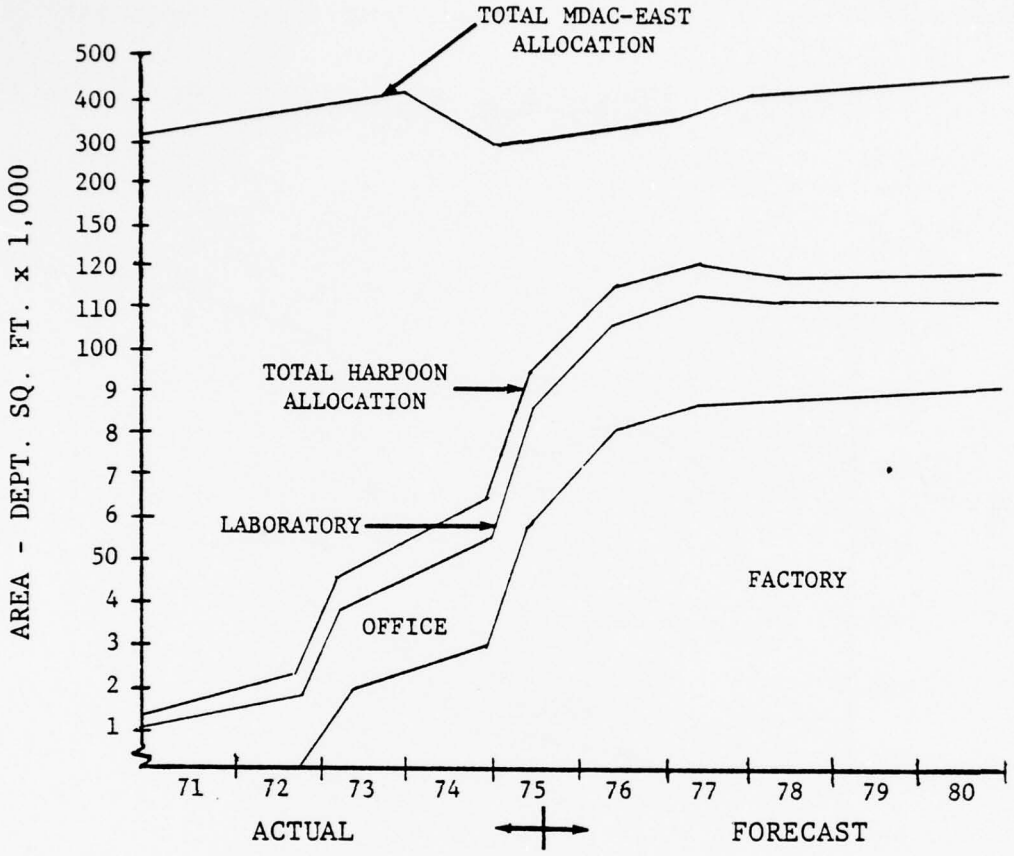
MDAC-East average unallowable expenditures for 1969-1975 were 10%.

Source: McDonnell Douglas Corporation

(2) Facilities

No special buildings had to be constructed for the Harpoon program. MDC believes that if it had not had these facilities and area available, it probably would not have responded to, or even received, the RFP. The Harpoon Area Allocation chart (Figure B-1) indicates the actual Harpoon floor space used in the factory, office and laboratory, vs. total MDAC-East area, and what Harpoon and MDAC-East floor

FIGURE B-1. HARPOON AREA ALLOCATION
*MDAC-EAST AREA ALLOCATION



*St. Louis Facility Only - Excludes Tulsa & MCAIR Fab Shop

space used in the factory, office and laboratory, vs. total MDAC-East area, and what Harpoon and MDAC-East floor space is anticipated. Harpoon facilities represent company resources that are not available to the company's other product lines.

(3) Working Capital

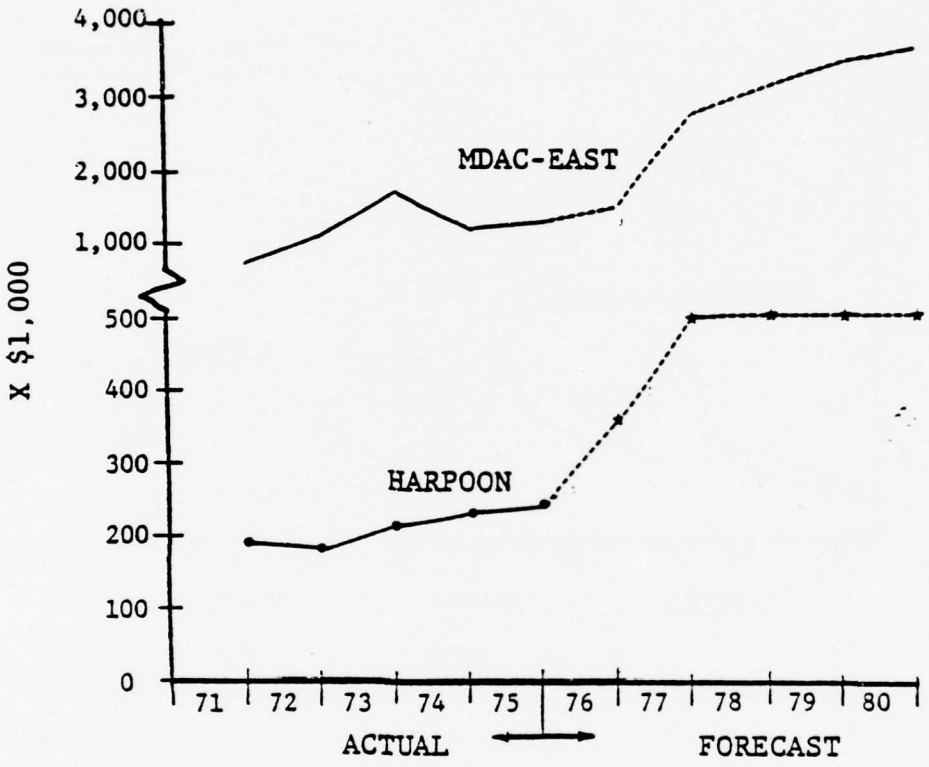
The Harpoon Program Design and Weapon System Development (WSD) phases were Cost Plus Incentive Fee (CPIF). MDC billed the Government every other week and was paid by the Navy within two days of each invoice. In June 1975, the Pilot Production Program was converted to a Fixed Price Incentive Program.

TABLE C-2. F-16 FACILITY PLAN: FUNCTIONAL SUMMARY

(4) Capital Investment

The MDAC-East Capital Investment (Figure B-2) shows the cumulative dollars committed to Harpoon through 1975 vs. total MDAC-East capital investment, and a forecast of additional capital expenditures required through 1980.

FIGURE B-2. MDAC-EAST CAPITAL INVESTMENT (TOTAL AND HARPOON) CUMULATIVE



Source: McDonnell Douglas Corporation

The following list of equipment represents the type of capital equipment that will be purchased in 1976 for the Harpoon program:

Arc Welder (Replacement)

Drill, Nut Plate (New)

Riveter, Drive-Matic (New)

2. Original Analysis

Analyzer Circuit (Replacement)

Marker and Cutter Tube (New)

Riveter, Nut Plate (New)

Band-Saw Cut-Off (New)

Miscellaneous Equipment, Mfg Support (Replacement).

The Harpoon capital investment for 1977 will be similar to that listed above. On all programs of Harpoon's magnitude, some equipment is always furnished by the Government, and Government-furnished services/facilities are sometimes used. The main piece of capital equipment furnished to MDAC by the Navy is a Missile Subsystem Test Set (MSTS) valued at about $3 million. In addition, MDAC-East is currently operating under a rent-free use of Government-owned facilities (Contract No. NAS 0-2539(f), which has a value of $1,467,000 for equipment in use).

(b) Contractual Relationships

(1) Type of Contract Used

Table B-5 shows, by program phase, key contractual information.

TABLE B-5. HARPOON PROGRAM: KEY CONTRACTUAL INFORMATION

	Design	Weapon System Development	Pilot Production
Type of Contract	CPIF	CPIF	CPIF changed to FPI
Target Cost	$60.4M	$109M	$68.4M
Ceiling Cost (% of Target)	N/A	N/A	120%
Share Lines (% Cost)	80/20%	80/20%	55/45%
Escalation Clause	No	No	No

Source: McDonnell Douglas Corporation

TABLE C-3. DEPRECIATION RATES

(2) Special Clauses

The special clauses for each of the Harpoon Program Phases are shown in Table B-6. It should be noted that although MDC did not have a negotiated initial production contract at the date of this information, these clauses are still anticipated.

TABLE B-6. HARPOON PROGRAM: SPECIAL CLAUSES

	Program Phase			
	Design	WSD	P.P.	I.P.
Anti-Claims (7-103.8)	X	X	X	X
Change (7-103.2)	X	X	X	X
CASB Regulations (7-104.83(a)(B))	X	X	X	X
Government Specifications (MIL Standards)	X	X	X	X
Disputes Clause (7-103.12)	X	X	X	X
CSCS (7-104.87)	X	X	X	X

Source: McDonnell Douglas Corporation

(3) Going-in Profit Rates

For the Harpoon program, the Navy established the specific target fee. The rates for each phase are shown in Table B-7.

The cost-share ratio for the Design, WSD and PP phases was on a 80% (Gov't), 20% (Contractor) basis. Performance under the Design and WSD phases was based upon missiles striking the target at the following rates:

50% hits - Min. Performance or 0% Fee

70% hits - Target Performance or 3% Fee

90% hits - Max. Performance or 6% Fee.

Any percentage of target hits in between was calculated on a straight line allocation.

R40A

TABLE B-7. HARPOON PROGRAM: TARGET FEES

Design Fee Rates	Min	Target	Max
Cost	0%	5%	7%
Performance	0%	3%	6%
Total	0%	8%	13%

Weapon System Fee Rates	Min	Target	Max
Cost	0%	5%	7%
Performance	0%	3%	6%
Total	0%	8%	13%

Pilot Production Fee Rates	Min	Target	Max
Cost	0%	8%	10%
Total	0%	8%	10%

Source: McDonnell Douglas Corporation

(c) Impact of Foreign Military Sales (FMS) Considerations

The following benefits can be realized from FMS:

- Economic
  - lower unit cost for U. S. hardware
  - improved balance of payments
  - tax benefits
  - increased employment
  - Government R&D recovery
- Military
  - operational flexibility
  - simplified logistics
  - improved Allied mutual security.

MDC's FMS have a potential dollar volume over the life of the program of between $600 million and one billion dollars. Harpoon was released for sale overseas while still in the early stages of development; its larger production base, related directly to foreign sales, is expected to result in a $17 million saving to the DoD in FY 1976. MDC estimates that the U. S. Navy will realize a savings of approximately 14% on each missile and all support equipment; the total potential benefits to the U. S. Government could be $.85 for every $1.00 of foreign sales. This figure of $.85 is made up of a direct return to the Government via R&D Recovery, Contract Income Tax, Personal Income Tax and indirect return in the form of U. S. Navy cost savings from the additional missile sales (the 14% mentioned above).

(d) Market Projection

MDC's marketing analysis in 1964-1967 indicated a DoD need and large FMS market for a missile with Harpoon's capability. The award of the Harpoon contract and subsequent Harpoon sales have proven MDC's marketing forecast correct. The projected rate of Navy and FMS sales through the FY 1981 buy is approximately 3,000, with accompanying ground support equipment. MDAC-East's operating plan for Harpoon sales for 1975-1980 is shown in Table B-8.

TABLE B-8. PROJECTED HARPOON SALES
(Millions)

CY	Sales
1975	$ 85
1976	$ 123
1977	$ 192
1978	$ 202
1979	$ 108
1980	$ 214

Source: McDonnell Douglas Corporation

MDAC-East is currently delivering missiles under the Pilot Production contract, with deliveries under the initial production contract scheduled to begin in mid-1976.

Actual and planned deliveries for the missile are shown in Table B-9.

TABLE B-9. HARPOON MISSILE DELIVERIES

	Contract Quantity			Planned Quantity							
	Design	WSD	FY75	FY76	FY7T	FY77	FY78	FY79	FY80	FY81	Total
U.S. Navy	12	40	100	170	80	350	480	480	480	280	2,472
FMS	-	-	-	112	24	240	144	108	84	84	796
Total	12	40	100	282	104	590	624	588	564	364	3,268

Source: McDonnell Douglas Corporation

While FMS sales are about 25% of total expected sales, MDC personnel stated that their main incentive was the prospect of U. S. Navy Sales.

3. The F-15 Fighter Program

The F-15 Eagle is a single-place, fixed wing all-weather air superiority fighter with secondary ground attack capability. The F-15 program was the first large Air Force production program to operate under the DoD demonstration milestone concept, which defers a production commitment until the pacing technology is demonstrated. The 555th Tactical Fighter Training Squadron at Luke AFB, Ariz., has now received its full quota of F-15s and achieved initial operational capability (IOC). The first production Eagle - the 21st aircraft - was delivered to the squadron in mid-November 1974, after nearly five years of R&D that included more than 3,300 flights totalling over 3,400 hours. After achieving IOC, the 555th Squadron assumed responsibility for training future Eagle pilots using its standard complement of single and two-place versions.

Concurrently, the first operational Eagle wing is being activated at Langley AFB, Va. This wing is scheduled to begin receiving its F-15s in January 1976, and to become the main back-up base for Eagle squadrons in all the deployed commands. The second operational wing will be the first front-line Eagle unit deployed on a top-priority

basis to central Europe, to counter advanced new aircraft entering the Soviet and Warsaw Pact inventories.

A history of the program from 1965 is given in Figure B-3. It should be noted that McDonnell Douglas was not one of the two recipients of the second concept formulation study in 1967.

(a) Capital Investment

Capital investments at McDonnell Douglas are justified more on a line-of-business basis than for the sake of a single program. The F-15 investment was necessitated by the production rates required by the contract.

The F-15 era capital investments made by McDonnell Aircraft Company are listed in Table B-10. Key items are shown in Table B-11.

As Tables B-10 and B-11 indicate, the majority of the capital investment was for upgrading the fabrication facilities. One feature of this upgrading was the conversion from Numerical Control (NC) to Direct Numerical Control (DNC). The NC system had used a tape encoded with instructions for the machine. Under DNC, the cutting tool is controlled from a central computer, the memory bank of which has all the information necessary to produce the required parts. The conversion to DNC has decreased the time required for machine repair or maintenance from 15% to 5%. Of that 15% down-time, two-thirds was related to tape-reading and electronics problems. DNC removes the tape system from the shop, and allows feedback circuits to control cutting speed and monitor the cutting process. When conversion to DNC is complete, MDC will have 24 five-axis gantries, plus five other five-axis cutting machines under DNC control, or about 22% of the western world's five-axis machines.

(b) Contractual Relationship

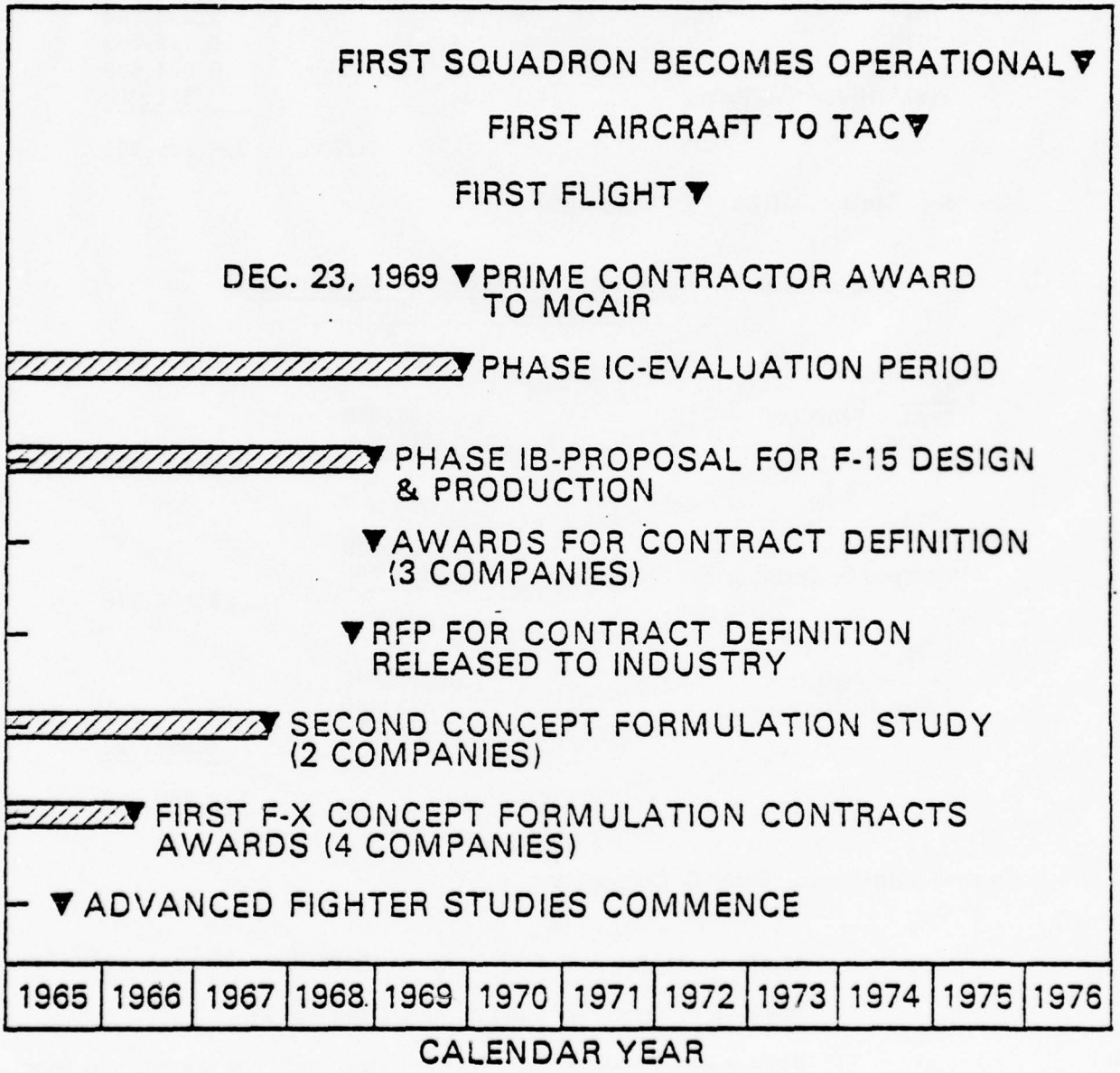
A number of special features of the F-15 contract are described below:

(1) Terms

CPIF covered the Development (D), and Development, Testing and Evaluation (DT&E) portion of the contract. The target fee was set

FIGURE B-3.

F-15 History



Source: McDonnell Douglas Corporation

TABLE B-10. F-15 CAPITAL ASSET OBLIGATIONS

Calendar Year	No. Items	Amount
1970	133	$ 1,983,266
1971	74	1,824,124
1972	52	5,333,708
1973	64	9,432,392
1974	55	9,604,633
1975 (Budgeted Items)	31	811,400
	TOTAL	$28,989,523

Source: McDonnell Douglas Corporation

TABLE B-11. F-15 CAPITAL ASSET OBLIGATIONS: KEY ITEMS (OVER $500,000)

1972		
5-Axis Profilers	$ 3,136,000	
Autoclave	711,840	
		$ 3,847,840
1973		
	$ 5,763,116	
Composite Bonding Facility	2,332,000	
		8,095,116
1974		
5-Axis Profilers	$ 6,019,000	
Laser Cutter	838,400	
		6,857,400
		$18,800,356

Source: McDonnell Douglas Corporation

at 8% of target cost with a 90/10 share line. The maximum fee was 12% of target cost and minimum fee was 2%.

FPIF covered the tooling, test articles, and first operational wing of aircraft segments of the program. The fee was set at 9% of

initial target cost, with the target cost reset 90 days after the delivery of a specified aircraft. For the production of the first operational wing, the share line was changed to 85/15.

(2) Limitation of Government Obligation

This provision applied to R&D (3600 Funds) only. It established a maximum Government funding obligation for FYs 1970 and 1971, and required the contractor to continue to perform as long as the Government supplied funds according to the plan. The contractor could not delay or stop work in the event of an overrun. The Government would fund overruns in future fiscal years. Meanwhile, the contractor would have to absorb financing charges and risk program reductions. Under this clause, the Government was not obligated to fund the overrun if McDonnell Douglas incurred costs in excess of funding and the Air Force terminated the contract.

(3) Total System Performance Responsibility

MDC had total F-15 system responsibility per system specification, a responsibility that entailed engine integration, and any correction of deficiencies.

(4) Abnormal Fluctuations in the Economy

The FY 1975 and FY 1976 option prices through three wings of aircraft have been based on a projected inflationary trend for labor and material from 1969 through 1977. Option ceiling prices for the second and third wings can be adjusted if the actual trend varies from this projection.

(5) Award Fee

The sum of $2 million is available at $400,000 per year for good contract performance. The decision is made by a board chaired by the Secretary of the Air Force. MDC has been awarded about $1.66 million in award fees to date.

(c) Market Projection

The price of the Eagle's outstanding performance is high, and, as of April 1975, the USAF was limiting its planned procurement to 729 units, of which every seventh aircraft is a two-place TF-15. The price breakdown for the F-15's $12.5 million

fly-away cost in FY 1976 includes: airframe, $5.4 million; engineering change proposals, $600,000; engines and accessories, $4 million; avionics, $2.2 million; and other GFE, $300,000. Of the projected 729 unit buy, the first 164 were funded in FYs 1973, 1974 and 1975. DoD has raised its FY 1976 request from 90 to 108, with an additional 24 for the FY 1976 transfer period. The FY 1977 request has been re-scheduled to 108 F-15s. The FY 1978 request is now planned at 108, FY 1979 at 108, and the final 109 are scheduled for FY 1980.

The USAF may be forced by pressure from Congress and civilians in DoD to make up the number of fighters it needs with some of the 650 F-16 lightweight aircraft now scheduled. On the other hand, the USAF may be permitted to increase its Eagle buy when the capabilities and real costs of both aircraft can finally be compared on a firm basis. Such comparisons are unlikely before General Dynamics completes F-16 development.

MDC estimates the potential domestic and international sales for the F-15 to be 1150 and 695 aircraft, respectively. Table B-12 lists the funds committed to date to the F-15 Program.

TABLE B-12. F-15 PROGRAM: FUNDS COMMITTED
(MILLIONS)

1)	DDT&E	$ 657
2)	Test A/C & Support	518
	Total 3600 Funds	1,175
3)	Aircraft	614
4)	Rate Tooling	27
5)	Program Management	6
6)	Trainers/Training	5
7)	Data	36
8)	AGE	62
9)	PMC Data	1
	Total 3010 Funds	751
10)	FY 1975	524
	Total Contract	$2,450

Source: McDonnell Douglas Corporation

C. GENERAL DYNAMICS CORPORATION - F-16 FACILITY PLAN

1. Introduction

This case study is limited to the capital investment decisions involved in the F-16 Facility Plan for the General Dynamics Fort Worth Division. The aircraft is to be produced in a Government-owned plant (Air Force Plant No. 4) operated by General Dynamics. General Dynamics has also invested in peripheral facilities.

Within the context of the F-16 Program, the contractor sees the division of responsibilities for Plant No. 4 as follows:

- General Dynamics' Responsibility:
  - Operate Air Force Plant No. 4 under the existing facilities contract F33657-72-C-0811
  - Provide expansion facilities to achieve a target aircraft delivery rate of 15/6[1] A/C per month;
- Air Force Responsibility: Continue its facility programs for
  - Capital-type rehabilitation
  - Equipment modernization
  - Equipment replacement
  - Maintenance of the industrial base.

The assumed F-16 aircraft delivery schedule is given in Table C-1.

On the basis of the division of responsibilities described above and the delivery schedule in C-1, General Dynamics has produced an F-16 Facility Plan that includes:

- An expansion program to achieve a 15/6 aircraft production capability
- A modernization/replacement plan for Air Force Plant No. 4
- A Delta Requirements Plan to produce 30/6 aircraft per month, should third country buys make this necessary.

---

[1] 15/6 refers to the following delivery rates:

15/month for USAF
6/month for NATO Consortium

TABLE C-1. F-16 AIRCRAFT DELIVERY SCHEDULE

	FSD[1]			Production					
	1976	1977	1978	1979	1980	1981	1982	1983	1984
Annual - CY	1	4	7	86	186	235	235	193	41
Cumulative - CY	1	5	12	98	284	519	772	965	1006

[1]Full Scale Development

General Dynamics produced the F-16 Facility Plan under the following ground rules:

- Both the Government and General Dynamics would participate in operating AFP No. 4, General Dynamics expanding the facility to achieve the 15/6 A/C per month capability, and the Air Force modernizing or replacing Government equipment.
- All items are cost effective for the 1000 aircraft buy.
- The basic plan is for a production rate of 15/6 aircraft per month.
- The 30/6 aircraft-per-month plan assumes the implementation of the Air Force modernization/replacement plan.
- The production make-or-buy plan is essentially the same as Full Scale Development.
- Funding for facilities will be available for time-phasing as shown in the plan.

On the basis of the foregoing assumptions, General Dynamics analysts suggested the capital investment program of Table C-2.

The rest of this case study examines the financial analyses surrounding General Dynamics' capital investment decisions about the F-16 Facility Plan. The original analysis

TABLE C-2. F-16 FACILITY PLAN: FUNCTIONAL SUMMARY

Function	Funding ($000) Expansion 15/6 Mo	Modernization Program	Expansion 30/6 Mo
1. Material Handling & First Cut	$ 1,050	$ 1,060	
2. Machine Shop	5,647	16,965	$9,408
3. Sheet Metal		5,736	
4. Chemical Processing	800	550	
5. Composites & Plastics	519	160	438
6. Tube Bending		129	
7. Assembly	1,765	290	
8. Quality Assurance	675	2,260	
9. Tool Manufacturing	602	100	
10. Electrical Bench	56		16
11. Engineering & Administrative	4,799		
Total	$15,913	$27,250	$9,862
Grand Total		$53,025	

Source: General Dynamics Corporation

is discussed in Section 2; it found Government investment in the facilities modernization program more cost-effective than General Dynamics' investment. General Dynamics communicated this finding to OSD officials in a 28 January 1976 briefing. The questions raised by OSD during this briefing led to a subsequent analysis by General Dynamics (described in Section 3), reassessing the attractiveness of such investments in the light of certain changes in DoD policy.

2. Original Analysis

Financial trade-off calculations are given for two sets of machines in the Facility Plan, a five-axis three-spindle profile mill, and a two-coordinate measuring machine. The calculations are carried out under the following assumptions:

- Production Program
  - 998 production aircraft: rate 15/6 per month
  - Fixed price incentive contract: 70/30 sharing for first three years
- Corporate Cash Flow
  - Depreciation charged to overhead rates
  - Investment tax credit: 10%
  - Income tax: 48%.

For each set of machines, a cash flow analysis is carried out for two assumptions: first, that the investment in the machine(s) is made by General Dynamics, and second, that the investment in the machine(s) is made by the Government.

The terms used in the original analysis are self-explanatory, except for the depreciation schedules. The applicable General Dynamics depreciation rates for this type of equipment are given in Table C-3.

Figures C-1 to C-4 illustrate the cost/benefits analysis for the five-axis three-spindle profile mill. The block labeled Corporate on Figure C-2 presents the financial data based on General Dynamics' investment in the machines; the block labeled Government contains data based on the Government's investment.

Figure C-3 shows the result of cost/benefit analysis for a Government investment. Benefits to DoD are separated from those accruing to the whole Federal Government. Benefits accruing to DoD in the first three years represent 70% of the gross program savings. In the out-years, DoD gets 100% of the gross program savings, since a new contract with General Dynamics would establish a new cost base. Total benefits to the Government are the sum of the benefits to DoD as well as the taxes on General

TABLE C-3. DEPRECIATION RATES

Year	Method	7 Yrs. Class Life
1	DDB	.2857
2	DDB	.2857
3	SYD*	.3056
4	SYD*	.3600
5	SYD*	.4375
6	SYD*	.5556
7	SYD*	.7500
8	SYD*	1.0000

*This is the SYD Remaining Life Rate, which is applied to unrecovered cost (not gross cost).

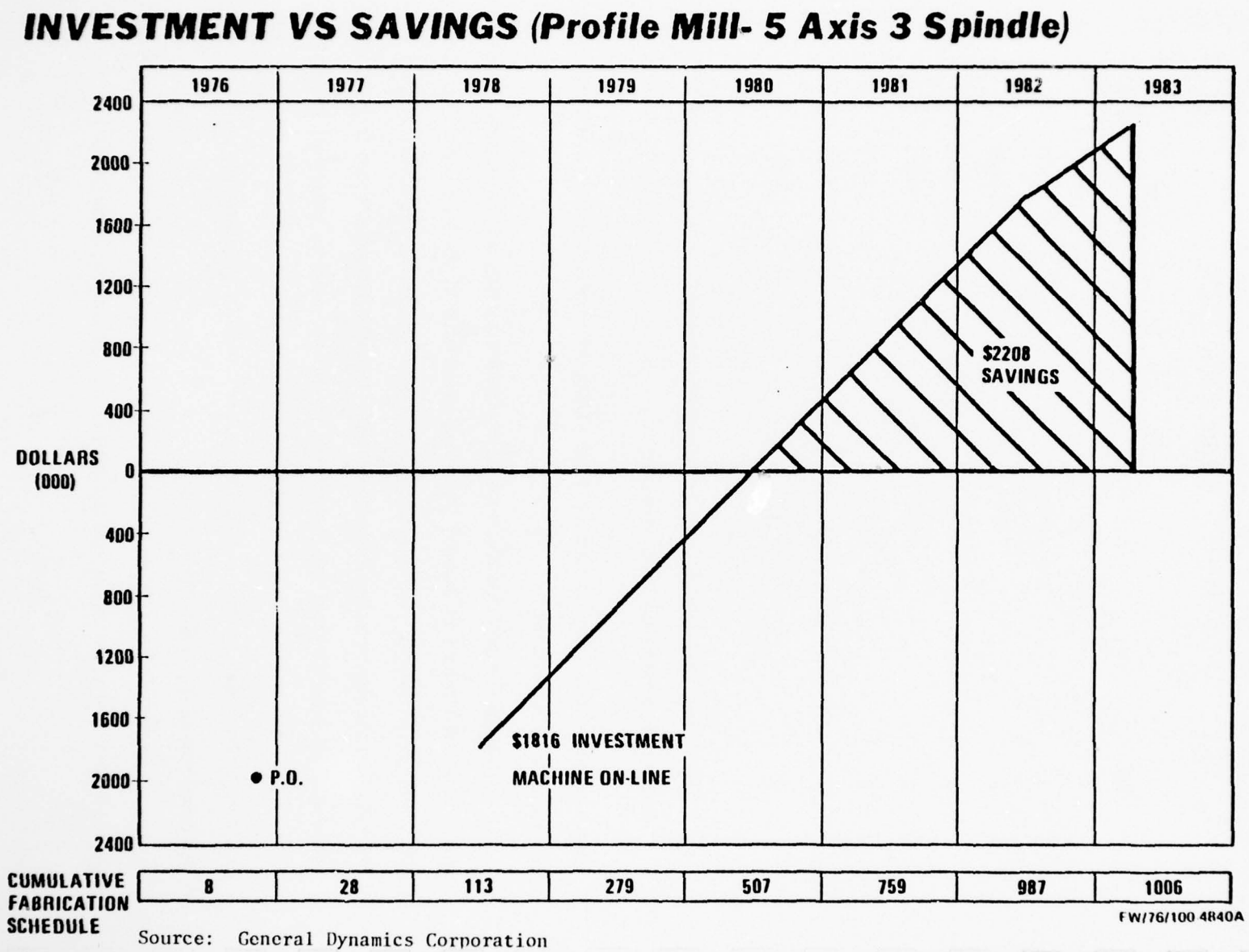
Source: General Dynamics Corporation

Dynamics' share of the gross program savings. Thus, the Government receives a high level of return for its investment.

Figure C-4 presents the result of cost/benefit analysis for a General Dynamics investment. The return to General Dynamics is made up of the Investment Tax Credit ($182,000), profit sharing for the first three years of the contract ($29,000, $70,000 and $86,000), and the depreciation charges as noted. General Dynamics would derive limited cost-reduction benefits from the investment; the return would be extremely low (2.2%). No return on investment has been calculated for the Government. However, both the DoD and the Government overall would clearly be the main beneficiaries of a General Dynamics investment in the profile mill.

Figures C-5 to C-7 present the same data for an investment in two-coordinate measuring machines. The results are similar to those for the profile mill investment.

FIGURE C-1.



Source: General Dynamics Corporation

FIGURE C-2.

FACILITY INVESTMENT (Profile Mill-5 Axis 3 Spindle)

CORPORATE

($000)	1977	1978 *	1979	1980	1981	1982	1983
BOOK VALUE		$1816	$1557	$1112	$ 772	$ 494	$ 278
DEPRECIATION		259	445	340	278	216	
GROSS SAVINGS		447	894	894	894	894	
NET PROGRAM SAVINGS		188	449	554	616	678	
GOVT SAVINGS		159	379	468	616	678	
CONTRACTOR SAVINGS (Less Tax)		29	70	86	- 0 -	- 0 -	

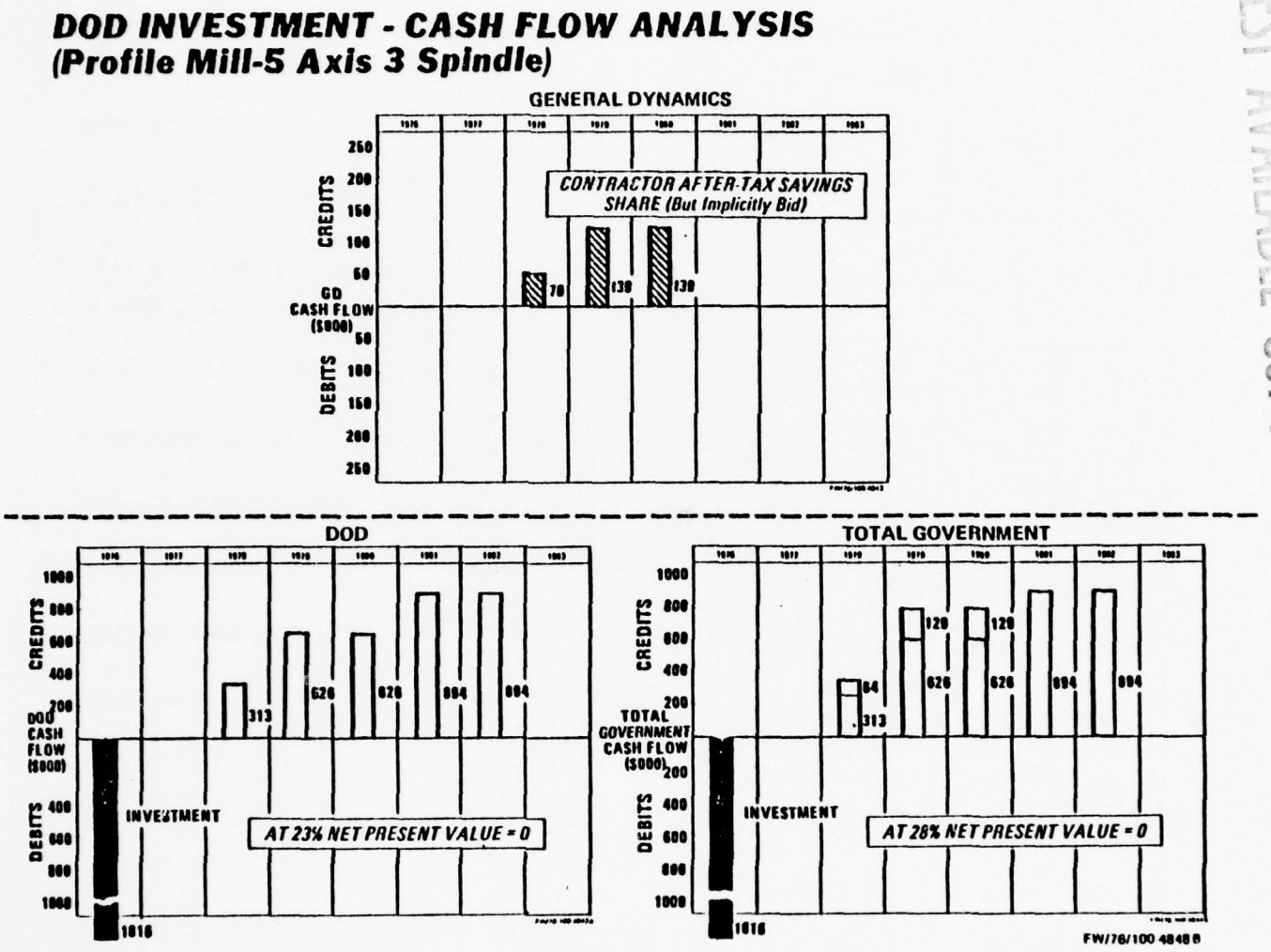
** PLUS INVESTMENT TAX CREDIT 182*

GOVERNMENT

GROSS PROGRAM SAVINGS		$ 447	$ 894	$ 894	$ 894	$ 894	
GOVT SHARE		377	755	755	894	894	
CONTRACTOR SHARE (Less Tax)		70	139	139	–	–	–

Source: General Dynamics Corporation

FIGURE C-3.



Source: General Dynamics Corporation

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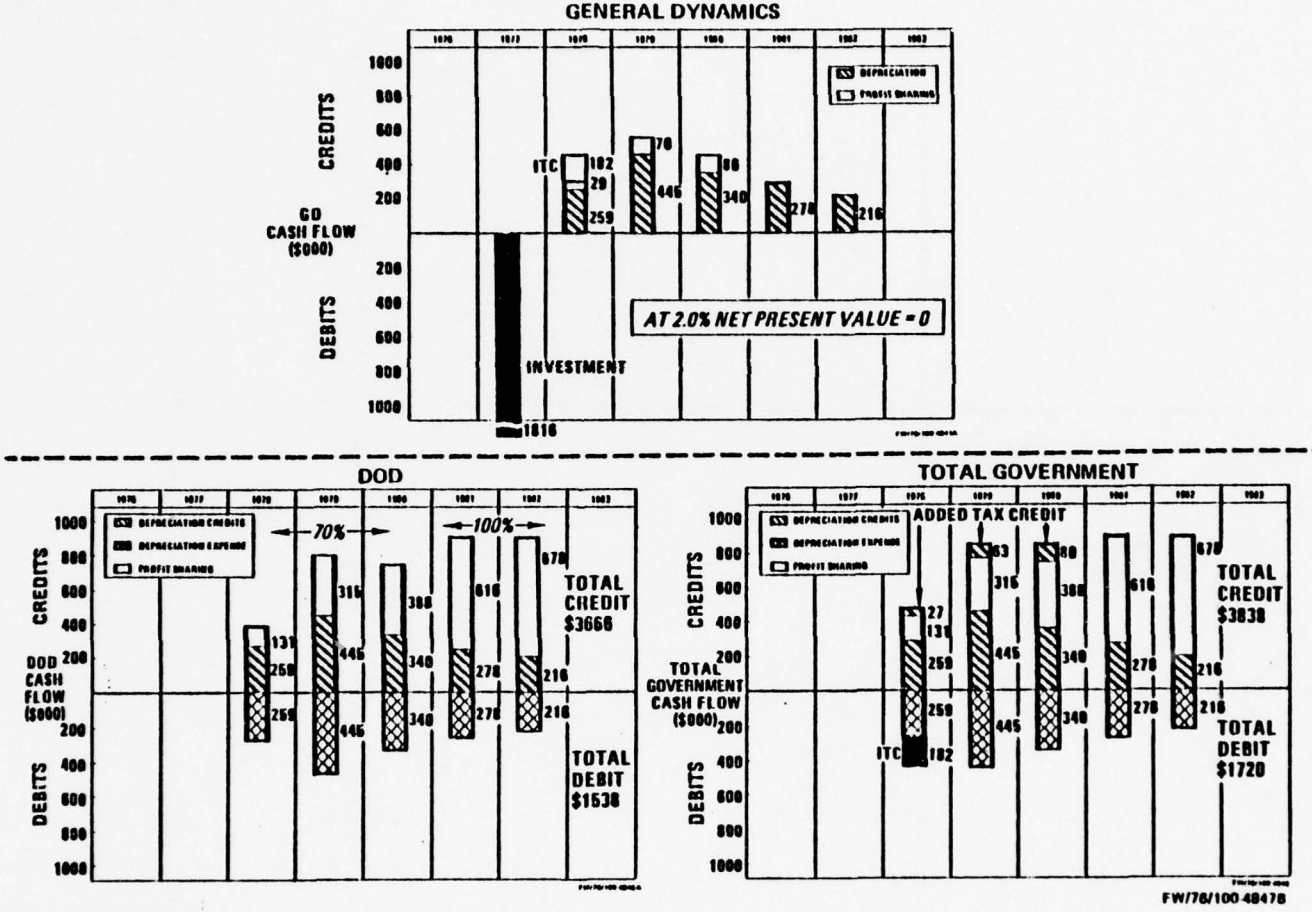
FIGURE C-4.

GENERAL DYNAMICS INVESTMENT - CASH FLOW ANALYSIS (Profile Mill-5 Axis 3 Spindle)



Source: General Dynamics Corporation

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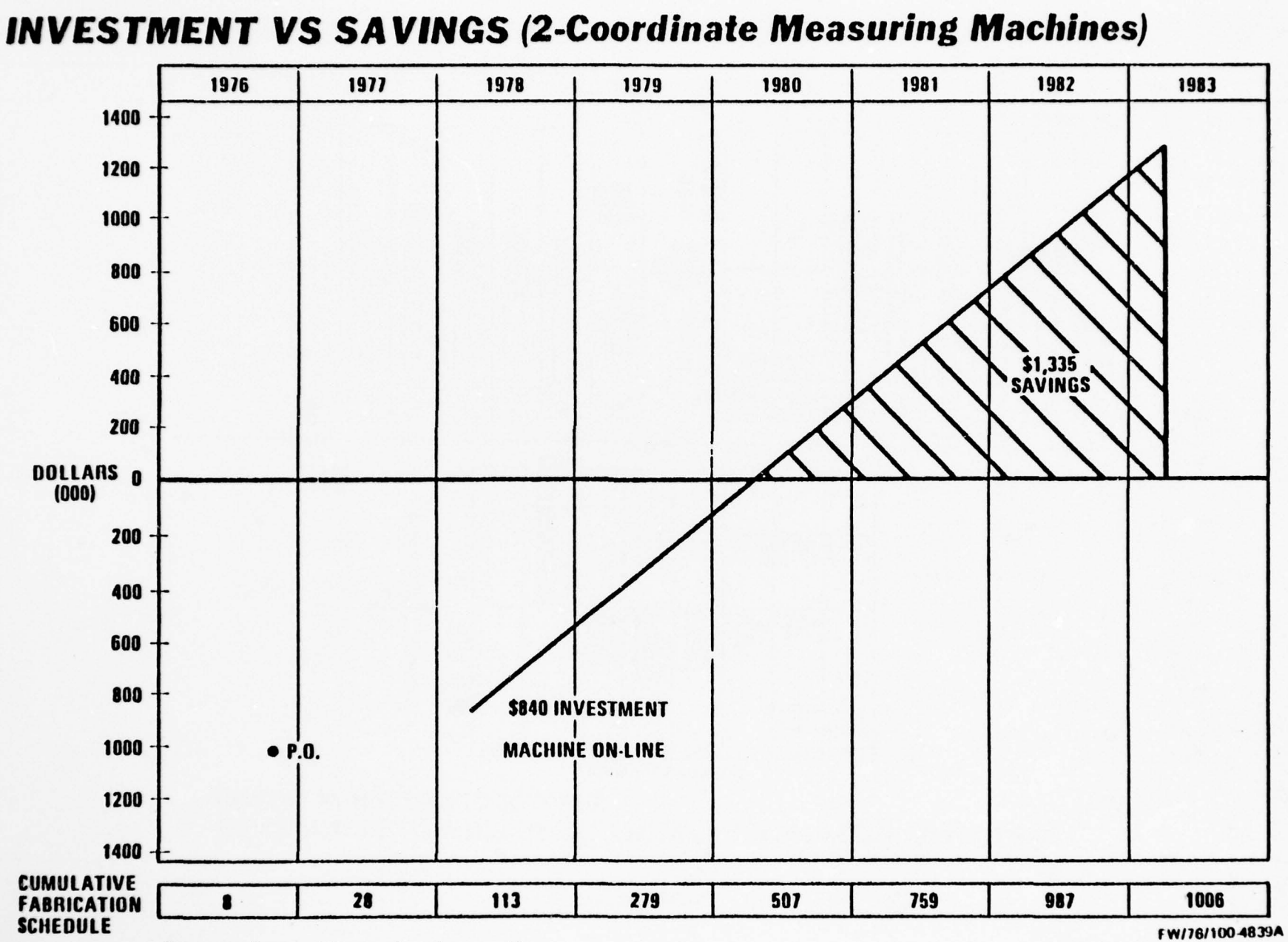
FIGURE C-5.



Source: General Dynamics Corporation

FIGURE C-6.

FACILITY INVESTMENT (2-Coordinate Measuring Machines)

CORPORATE

($000)	1977	1978*	1979	1980	1981	1982	1983
BOOK VALUE		$ 840	$ 720	$ 514	$ 357	$ 228	$ 128
DEPRECIATION		120	206	157	129	100	
GROSS SAVINGS		435	435	435	435	435	
NET PROGRAM SAVINGS		315	229	278	306	335	
GOVT SAVINGS		266	193	235	306	335	
CONTRACTOR SAVINGS (Less Tax)		49	36	43	-0-	-0-	

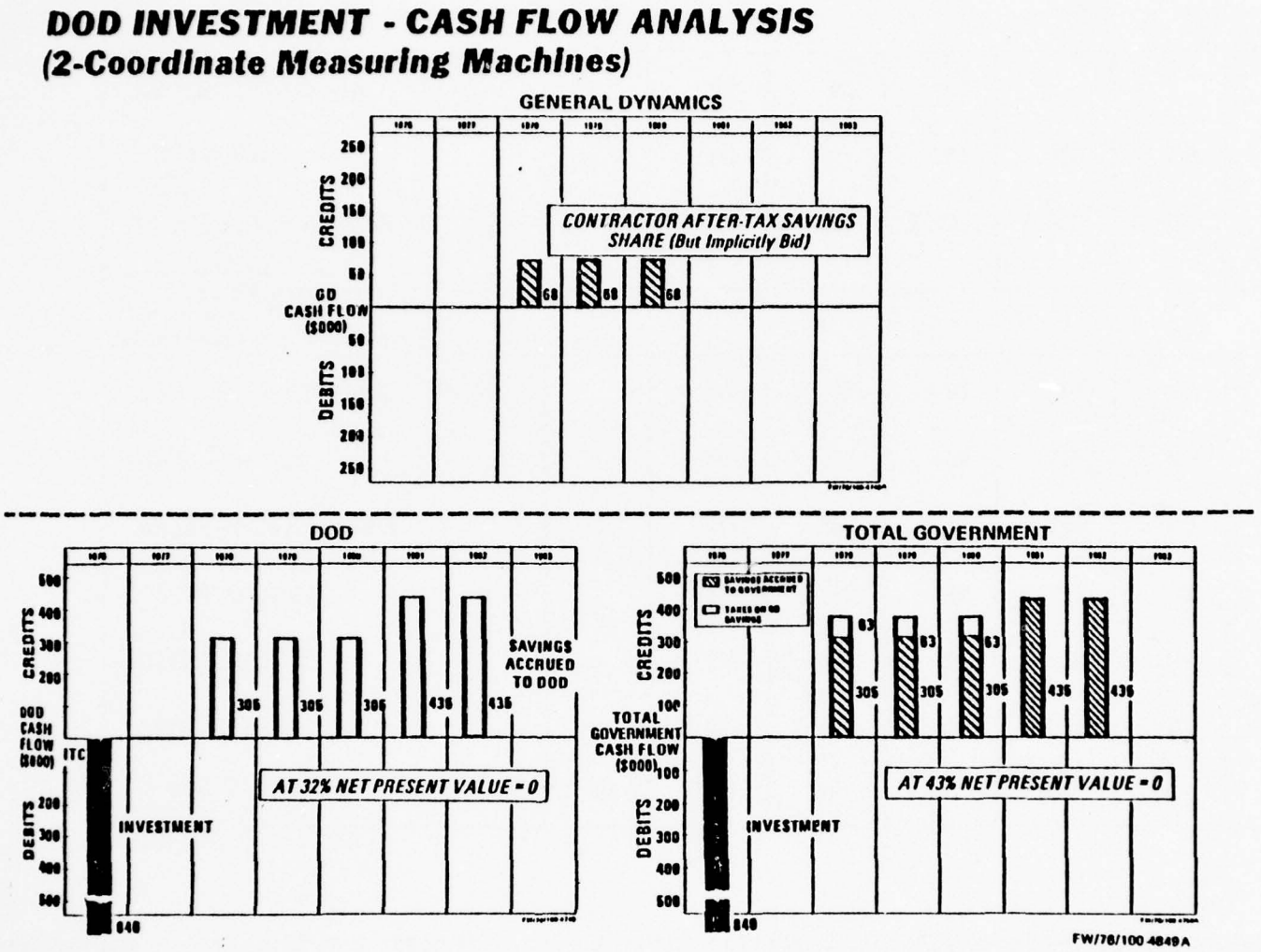
** PLUS INVESTMENT TAX CREDIT 84*

GOVERNMENT

GROSS PROGRAM SAVINGS		$ 435	$ 435	$ 435	$ 435	$ 435	
GOVT SHARE		367	367	367	435	435	
CONTRACTOR SHARE (Less Tax)		68	68	68	–	–	

Source: NIFCR, p. 26

FIGURE C-7.



Source: NIFCR, p. 28

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3. Subsequent Analysis

Some variants of the original analysis, concerning the profile mill, are explained below. The variants were intended to test the influence of certain DoD policy changes on the attractiveness of F-16-related capital investments for General Dynamics.

A few terms need to be defined in order to understand the analysis of policy options which follows.

- Imputed Interest: The Cost Accounting Standards Board has issued a Cost Accounting Standard (CAS 414), which treats the cost of money as part of the cost of capital. The standard allows payment of an imputed cost of money, equal to some "risk-free" rate, for capital used in performing negotiated Government contracts. In the case of the F-16, it is assumed that an 8% rate would be paid on the book value of any required program facility investment made by General Dynamics.
- CAS 409: This cost accounting standard has been interpreted to permit the depreciable life of capital assets to be equal to their "economic" life. Economic life does not necessarily equate with the periods allowed by the IRS. In this case, the profile mill would be depreciated over 15 years.

The analyses are similar to those presented in Figures C-1 to C-6 for a General Dynamics investment. The policy options analyzed are:

- The contract is carried out with an 8% imputed interest paid on investment net book value (Figure C-8).
- The share line is changed to 10/90 for three years (Figure C-9).
- The share line is changed to 10/90 for the life of the program (Figure C-10).
- Three year accelerated depreciation is used and accepted by the IRS (Figure C-11). Share line is 70/30.
- The original contract is modified to allow 8% imputed interest paid on investment book value and three year accelerated depreciation (Figure C-12). Share line is 70/30.
- CASB 409 is enforced, resulting in a 15-year depreciation life for the asset (the IRS requires a similar depreciation life) (Figure C-13).

FIGURE C-8.

FACILITY INVESTMENT (Profile Mill-5 Axis 3 Spindle)

- 8% Imputed Interest On Book Value
- 70/30 Sharing

CORPORATE

($000)	1977	1978 *	1979	1980	1981	1982	1983
BOOK VALUE		1816	1557	1112	772	494	278
DEPRECIATION		259	445	340	278	216	
INTEREST EXPENSE		145	125	89	62	40	
GROSS SAVINGS		447	894	894	894	894	
NET PROGRAM SAVINGS		43	324	465	554	638	
GOVT SAVINGS		36	273	392	554	638	
CONTRACTOR SAVINGS (Less Tax)		7	51	73	-0-	-0-	

ROI – 12.3%

*PLUS INVESTMENT TAX CREDIT 182

Source: General Dynamics Corporation

FIGURE C-9.

FACILITY INVESTMENT (Profile Mill-5 Axis 3 Spindle)

•10/90 Sharing (3 Years)

CORPORATE

($000)	1977	1978	1979	1980	1981	1982	1983
BOOK VALUE		1816	1557	1112	772	494	278
DEPRECIATION		259	445	340	278	216	
INTEREST EXPENSE		-0-	-0-	-0-	-0-	-0-	
GROSS SAVINGS		447	894	894	894	894	
NET PROGRAM SAVINGS		188	449	554	616	678	
GOVT SAVINGS		100	239	295	616	678	
CONTRACTOR SAVINGS (Less Tax)		88	210	259	-0-	-0-	

ROI – 11.6%

*PLUS INVESTMENT TAX CREDIT 182

Source: General Dynamics Corporation

FIGURE C-10.

FACILITY INVESTMENT (Profile Mill-5 Axis 3 Spindle)

- 10/90 Sharing Over Life Of Program

CORPORATE

($000)	1977	1978 *	1979	1980	1981	1982	1983
BOOK VALUE		1816	1557	1112	772	494	278
DEPRECIATION		259	445	340	278	216	
INTEREST EXPENSE		-0-	-0-	-0-	-0-	-0-	
GROSS SAVINGS		447	894	894	894	894	
NET PROGRAM SAVINGS		188	449	554	616	678	
GOVT SAVINGS		100	239	295	328	361	
CONTRACTOR SAVINGS (Less Tax)		88	210	259	288	317	

ROI – 20%

* PLUS INVESTMENT TAX CREDIT 182

Source: General Dynamics Corporation

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INVESTMENT POLICY FOR COST REDUCTION,(U)
DEC 76 H E BERTRAND, J C LAFRANCE SD-321
UNCLASSIFIED LMI-76-9 NL

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FIGURE C-11.

FACILITY INVESTMENT (Profile Mill-5 Axis 3 Spindle)

- 70/30 Sharing
- Accelerated Depreciation

CORPORATE

($000)	1977	1978 *	1979	1980	1981	1982	1983
BOOK VALUE		1816	1362	454	-0-	-0-	-0-
DEPRECIATION		454	908	454	-0-	-0-	
INTEREST EXPENSE		-0-	-0-	-0-	-0-	-0-	
GROSS SAVINGS		447	894	894	894	894	
NET PROGRAM SAVINGS		(7)	(14)	440	894	894	
GOVT SAVINGS		(6)	(12)	371	894	894	
CONTRACTOR SAVINGS (Less Tax)		(1)	(2)	69	-0-	-0-	

ROI – 9.2%

*PLUS INVESTMENT TAX CREDIT 182

Source: General Dynamics Corporation

FIGURE C-12.

FACILITY INVESTMENT (Profile Mill-5 Axis 3 Spindle)

- 8% Imputed Interest On Book Value
- 70/30 Sharing
- Accelerated Depreciation

CORPORATE

(S000)	1977	1978	1979	1980	1981	1982	1983
BOOK VALUE		1816	1362	454	-0-	-0-	-0-
DEPRECIATION		454	908	454	-0-	-0-	-0-
INTEREST EXPENSE		145	109	36	-0-	-0-	-0-
GROSS SAVINGS		447	894	894	894	894	
NET PROGRAM SAVINGS		(152)	(123)	(404)	894	894	
GOVT SAVINGS		(128)	(104)	(341)	894	894	
CONTRACTOR SAVINGS (Less Tax)		(24)	(19)	(63)	-0-	-0-	

ROI – 14.1%

* PLUS INVESTMENT TAX CREDIT 182

Source: General Dynamics Corporation

FIGURE C-13.

FACILITY INVESTMENT (Profile Mill-5 Axis 3 Spindle)

- **15 Year Straightline Depreciation**

COST ACCOUNTING STANDARD -- 409

CORPORATE

($000)	1977	1978	1979	1980	1981	1982	1983
BOOK VALUE		1816	1695	1574	1453	1332	1211
DEPRECIATION		61	121	121	121	121	
INTEREST EXPENSE		-0-	-0-	-0-	-0-	-0-	-0-
GROSS SAVINGS		447	894	894	894	894	
NET PROGRAM SAVINGS		386	773	773	773	773	
GOVT SAVINGS		326	652	652	773	773	
CONTRACTOR SAVINGS (Less Tax)		60	121	121	-0-	-0-	

NEGATIVE – ROI

*PLUS INVESTMENT TAX CREDIT 182

NOTE: ROI based on depreciation life = 3.8%

Source: General Dynamics Corporation

Government investment in either set of machines would thus yield a high level of return to the Government. Under present contract conditions, the Government is also the main beneficiary of investment by General Dynamics.

Table C-4 gives a summary of results for the cases where the investment is made by General Dynamics.

TABLE C-4. SUMMARY OF RESULTS (GENERAL DYNAMICS INVESTMENT)

Figure	Case	ROI
C-4	Profile Mill - Actual Contract	2.0%
C-7	2-Coordinate Measuring Machine - Actual Contract	5.0%
	Profile Mill	
C-8	Actual Contract and 8% Imputed Interest	12.3%
C-9	Actual Contract and 10/90 Sharing	11.6%
C-10	Actual Contract and 10/90 Sharing for Life of the Program	20.0%
C-11	Actual Contract, 3 Yr. Accelerated Depreciation, and 70/30 Sharing	9.2%
C-12	Actual Contract, 8% Imputed Interest, 3 Yr. Accelerated Depreciation, and 70/30 Sharing	14.1%
C-13	Actual Contract and CAS 409 (15 Yr. Dep.)	(Neg.)

D. BELL HELICOPTER COMPANY

1. Introduction

The Bell Helicopter Company, a subsidiary of Textron, Inc., is the largest helicopter manufacturer in the world. About 60% of all helicopters flying worldwide are Bell helicopters. Bell Helicopter was included in this study because it represents an important segment of the defense industrial base and because of its interesting past history.

The operating data for the Bell Helicopter Company are given in Table D-1. Bell moved to Texas at the beginning of the Korean conflict, and grew rapidly from 1952 to 1956. Six years of diminished overall sales followed. The Vietnam conflict provided a stimulus to helicopter sales, and Bell's sales to DoD increased more than four-fold. A period of retrenchment then followed, in which military sales fell to half their wartime value over a two-year span (1970-1971). In 1972, a third period of rapid expansion began, caused by increases in commercial sales.

The company survived two large DoD-related business cycles; its operations prospered, and fixed depreciation costs were not a major factor in overhead rates. The interesting question is how Bell managed to weather these large fluctuations in DoD sales, seemingly without adverse impact on its operations. The following section analyzes Bell's financial planning during the three major growth periods indicated above. Sections 3 and 4 describe, respectively, Bell's current investment decision-making process, and its market projections.

2. Analysis of Three Major Growth Periods

(a) The Korean Era

At the beginning of the Korean Conflict, Bell Helicopter built facilities in Texas to meet the DoD's growing need for helicopters. The total value of the facilities amounted to roughly $15 million, about $10 million being Government furnished property. Bell Helicopter invested about $5 million of company funds in the facilities under a

TABLE D-1. BELL HELICOPTER COMPANY: SELECTED OPERATING DATA, 1952-74

Year	SALES ($ THOUSANDS) US Govt. Sales	Other Sales	Total Sales	% Govt.	CAPITAL ADDITIONS Land, Bldgs. & Leasehold Improvmts.	Mach. & Eqpt.	Off. Furn. Eqpt. & Other	Total	ASSETS MIX Bell Prop.	Govt. Furn. Prop.	NUMBER OF EMPLOYEES
1952	$ 28,502	$ 2,277	$ 30,779	92.6%	$3,258	$ 143	$ 505	$ 3,906	$ 4,643	$ 704	*
1953	25,304	3,656	38,960	87.4	610	145	142	897	5,051	4,496	*
1954	26,884	4,090	30,974	86.8	550	65	71	686	5,568	7,640	*
1955	43,411	5,623	49,034	88.5	68	23	27	118	5,578	9,031	*
1956	49,952	8,032	57,984	86.1	135	26	103	264	5,954	9,110	*
1957	29,465	9,642	39,107	73.3	645	87	96	828	6,671	10,665	*
1958	28,392	7,306	35,698	79.5	262	158	137	557	7,845	10,516	*
1959	28,555	7,412	35,967	79.4	1,097	211	152	1,460	8,887	9,744	*
1960	42,881	8,160	51,041	84.0	80	380	244	704	2,198	9,429	3,229
1961	43,699	8,577	52,276	83.6	58	426	90	574	2,448	8,980	3,092
1962	46,604	8,791	55,295	84.1	138	400	220	758	3,225	8,917	3,675
1963	87,710	14,380	102,090	85.9	415	769	359	1,543	4,960	9,291	5,137
1964	134,349	15,831	150,180	89.5	1,085	983	361	2,429	7,389	9,598	5,751
1965	174,986	21,254	196,240	89.2	1,499	1,414	666	3,479	10,800	9,760	6,713
1966	292,861	27,157	320,018	91.5	3,832	3,600	910	8,342	19,322	20,170	9,630
1967	422,220	54,648	476,868	88.5	3,546	835	888	5,269	24,198	30,279	10,478
1968	455,540	59,286	514,826	88.5	3,439	2,449	972	6,860	31,328	30,954	10,919
1969	403,956	76,094	480,050	84.1	4,001	1,137	1,164	6,302	37,113	30,277	11,956
1970	386,590	68,095	454,685	85.0	1,945	1,299	1,094	4,338	40,855	29,196	11,300
1971	294,873	71,503	366,376	80.5	151	1,192	391	1,734	42,408	21,924	9,208
1972	231,650	101,574	333,224	69.5	291	1,065	107	1,463	43,550	20,335	7,770
1973	166,037	145,779	311,816	53.2	2,153	2,798	775	5,726	48,595	18,798	7,203
1974	148,375	212,371	360,746	41.1	3,694	3,935	4,989	12,618	60,768	18,324	9,111

*Not Available

Source: Bell Helicopter Company

Certificate of Necessity from the DoD. During the Korean Era, Bell's total sales about doubled to $58 million per year, of which 86% were Government sales.

In 1953, when active fighting in Korea ended, the DoD terminated most of its contracts with Bell Helicopter. Termination compensation was paid on a direct cost basis, hence, no compensation was received for unamortized facilities cost. Thanks to the Certificate of Necessity, most facilities costs had already been amortized, and Bell escaped relatively unscathed. Without the Certificate of Necessity, such an abrupt drop in DoD sales would have been most disruptive, since commercial sales then accounted for only about 20% of Bell's total business, and they, too, declined immediately after the Korean conflict.

(b) The Vietnam Era

In the mid-1960's, the Vietnam conflict intensified, and the helicopter became one of the Army's main weapon systems. As a result, the Army expressed a need for a production capacity of 150 helicopters/month at Bell. Such production required a large increase over existing capacity. Since no Certificate of Necessity was to be issued, Bell was faced with the risk of having to carry large unamortized facilities costs if the DoD market again collapsed. This risk was mitigated by the special nature of helicopter maufacturing, which requires transmission and blade manufacturing facilities, but allows great flexibility as to the fabrication of the rest of the ship.

Bell analysts were also reasonably confident that a $100 million sales level could be maintained, no matter what happened in Vietnam. They calculated that, with judicious use of leasing and subcontracting, a capital investment of $40 million was needed to bring the production rate up to the desired 150 helicopters/month. Of this amount, the Army furnished $20 million in property and equipment; this left a sum of $20 million of company funds to be amortized over the total business base, a burden that management felt confident of being able to support at the predicted $100 million sales level.

When the requirements of Vietnam started decreasing in the late 1960's, Bell was able to absorb a decrease in sales of nearly 30% over a four-year period, without undue problems caused by fixed depreciation costs. Manpower was cut by about 2500 during this period. Through planning, the company successfully weathered a major reversal in its business base. Bell was apparently practicing what Mr. J. B. Collinson, President of Textron, said about the defense business, "It is a business in which asset management is a key element. . ."[1]

(c) The Commerical Era

Since 1972, there has been a strong upsurge in the demand for commercial helicopters. Aviation Week (Sept. 29, 1975) mentions the following reasons for the increase: the worldwide surge in energy exploration and development; new uses for the helicopter in logging, shipping and heavy construction, which for the first time are economically feasible; and widespread introduction of new technology that promises to cut helicopter direct operating costs by up to 75%. From 1972 to 1974, Bell commercial sales doubled to more than $200 million. Bell is predicting that the commercial market will expand for at least the next four years.

On the basis of this prediction, Bell is now engaged in a major company-funded expansion program. The method used to justify the level of investment is the same used during the Vietnam era buildup. Bell has established a minimum sustainable sales level, is investing in production facilities to sustain this level, and will use subcontracting and leasing to fill in the gaps. Two main facilities presently being acquired are: the Machining Center for Transmissions, which will include new technology machines and provide additional capacity; and the Engineering Test Center, which will enhance Bell's capability in the new technologies of helicopter design.

3. Investment Decisions

The method of determining the given level of investment for major expansion is described in Section 2, above. Bell staff prepare the normal yearly capital budget; it is

[1]Letter to Deputy Secretary of Defense William P. Clements, Jr., August 22, 1975, p. 2.

consolidated at the Bell executive level, and presented to Textron for final approval. Along with this yearly capital budget, a five-year capital investment plan is also submitted to Textron.

In the preparation of the capital budget, the order of priority is: first, replacement of work equipment, and second, implementation of new, cost-reducing technologies. These priorities are affected by market forces and can change from year to year.

Those few items that are strictly cost-reducing offer special problems to Bell analysts. The same Bell facilities are used for both DoD and commercial work. To get the real value of the benefits flowing to the company, the cash flows of cost-reducing capital investments are downgraded by the amount of Government business on which they will be used. However, investment for cost reduction alone is infrequent, with the sting of competition or the need to upgrade technology usually being the driving force behind capital investment decisions.

As far as investment in capital assets for defense production is concerned, Bell believes that:

- CAS 409 will be a definite detriment to investment.
- Defense business is unpredictable and hence risky; Bell cannot justify large capital investments on the basis of prospective Government markets alone.
- An additional one to three percentage points in profits would not be a significant inducement to increased capital investment. The real incentive to investment lies in depreciation policies (e.g., accelerated depreciation).

4. Market Projections

Bell executives expect the commercial market to expand for at least the next four years. They see the Army market stabilizing somewhere around the present level. Although they anticipate that commercial sales will reach about 70% of total sales in 1975, and stay at that level for the next few years, they consider the Army market

essential. While they do not intend to become purely commercial producers, they will maintain a strong commercial base, if only to counter the oscillations of DoD sales.

PART III

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PART III

APPENDIX A

POTENTIAL INVESTMENT REQUIREMENTS FOR DEFENSE PRODUCTION

1. Introduction

Analysis of the Defense Industrial Base (DIB) has shown that defense industry has not been investing in new plant and equipment at the same rate as commercial industry. Since the mid-sixties, inflation has cut significantly into the buying power of the defense budget. In constant 1967 dollars, the FY 1976 procurement budget represents an approximate 53% decrease. This decrease, together with the general feeling among corporate officers that the percentage of total future sales to DoD will decline, has discouraged companies from making defense-related investments.

Recent revisions in DoD profit policy, e.g., DPC 76-3, are intended to escalate the level of new investment by defense industry. The purpose of the following analysis is to estimate the maximum annual level of new investment capital for FY 1977-1982 required to support defense sales at the same level as commercial sales, the minimum new equipment investment by defense industries, based on historically demonstrated rates, and the difference between them.

The extent to which DoD encourages the defense industry to increase its level of investment in the late seventies and early eighties will affect the capital market significantly. Nine percent of the investment demand required by all industry for equipment and facilities would be to meet non-productive EPA and OSHA regulations.[1] This demand for investment could so increase the cost of capital that industry's required ROI would reach a level where many potentially good investments would no longer be considered economically feasible.

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[1] Elliot S. Grossman, A Guide to the Determinants of Capital Investment with Special Reference to Defense Manufacturers, The Conference Board, N.Y., 1975, p. 16.

The historical investment-to-sales ratios and investment trends used in this appendix were obtained from the DIB study. All percentages were rounded to the nearest one-half. Readers familiar with the Profit '76 study will notice that its investment-to-sales ratios differ significantly from those calculated in the DIB study. This disparity is the result of two different definitions of investment. The DIB study, using total company data, defined investment as the annual expenditures for plant and equipment. Profit '76, which was limited to profit center data, defined investment as the annual total net book value of plant and equipment.

2. Assumptions

For the purpose of the calculations which follow, these assumptions were made:

- The ratios of annual new investment to sales for high-percent-defense companies (> 45% of total sales from defense sales) in the DIB study are representative of all investments related to defense sales. The averages during the years 1970 to 1974 (3.5%, excluding leases and 6%, including leases) will be valid for the FY 1977 to 1982 period.

- Commercial industry's investment ratios were used as the baseline for defense business investment on the assumption that active commercial competition will force investment decisions that emphasize productivity.

- The ratios of annual new investment to sales for low-percent-defense-companies (< 15% of total sales from defense sales) in the DIB study are representative of all investments related to commercial sales. The averages during the years 1970 to 1974 (16%, excluding leases and 17.5%, including leases) will be valid for the FY 1977 to 1982 period.

- Low-percent-defense companies generally deal in a more predictable and stable market, where profits are not tied as closely to costs. Therefore, they are more willing to invest to meet future demands, and have more incentive to reduce costs. The

ratio of investment to sales for this group was used to calculate the upper limit to which defense investment could be raised.

- Leases were included in total annual investment because they represent decisions to commit resources to plant and equipment.

- The Government will continue to invest in plant and equipment for use by defense contractors. The level of these investments will continue at the level of Government plant and equipment, measured as a percent of contractor plant and equipment, in use during 1970 to 1974. Based on DIB data, Government investment will equal about 7.5% of company investment during the FY 1977 to 1982 period. If the Government does not provide this investment, industry will be required to assume the responsibility.

- The volume of FMS, estimated by DoD to be approximately $7 billion in FY 1977, will decline, based on informal discussions with the DoD, at about 5% annually from FY 1978 to 1982. (FMS are included in projected sales.)

- Estimates of projected investment levels for FY 1977 to 1982 were based on existing profit policy. They do not attempt to measure the increases in investment to be realized from DPC 76-3.

- Contractor investment for special purpose equipment peculiar to a defense contract, and therefore directly charged, cannot be estimated; it appears to amount to so small a percentage of total investment that it can safely be assumed insignificant.

3. Potential Investment and Required Investment

To estimate the level of maximum potential investment, the ratios of investment (including leases) to sales for commercially-oriented companies were applied to projected defense sales. The resulting figures served as the annual upper limits against which projected annual new investments were compared. (See Table A–1.)

To project annual investment by the defense industry, the ratios of investment (including leases) to sales for defense-oriented companies were also applied to projected

defense sales. Government investment calculated as a percent of industry investment was then added to industry investment to arrive at the total projected investment.

The difference between maximum potential and total projected investments for defense business was computed. This represents the additional amount defense industry must invest for defense business if it is to be on a part with commercial industry. (See Figure A–1.)

TABLE A-1. INVESTMENT: POTENTIAL, PROJECTED, REQUIRED

(Billions FY 1977 Dollars)

FY	Projected Sales[1]	Potential Maximum Annual Inv. + Leases[2]	Projected Total Annual Inv. + Leases[3]	Industry's Annual Reqmnts. (Inv. + Leases)[4]
77	$34.0	$6.0	$2.1	$3.9
78	36.4	6.4	2.3	4.1
79	37.7	6.6	2.4	4.2
80	38.3	6.7	2.4	4.3
81	38.4	6.7	2.4	4.3
82	39.3	6.9	2.5	4.4

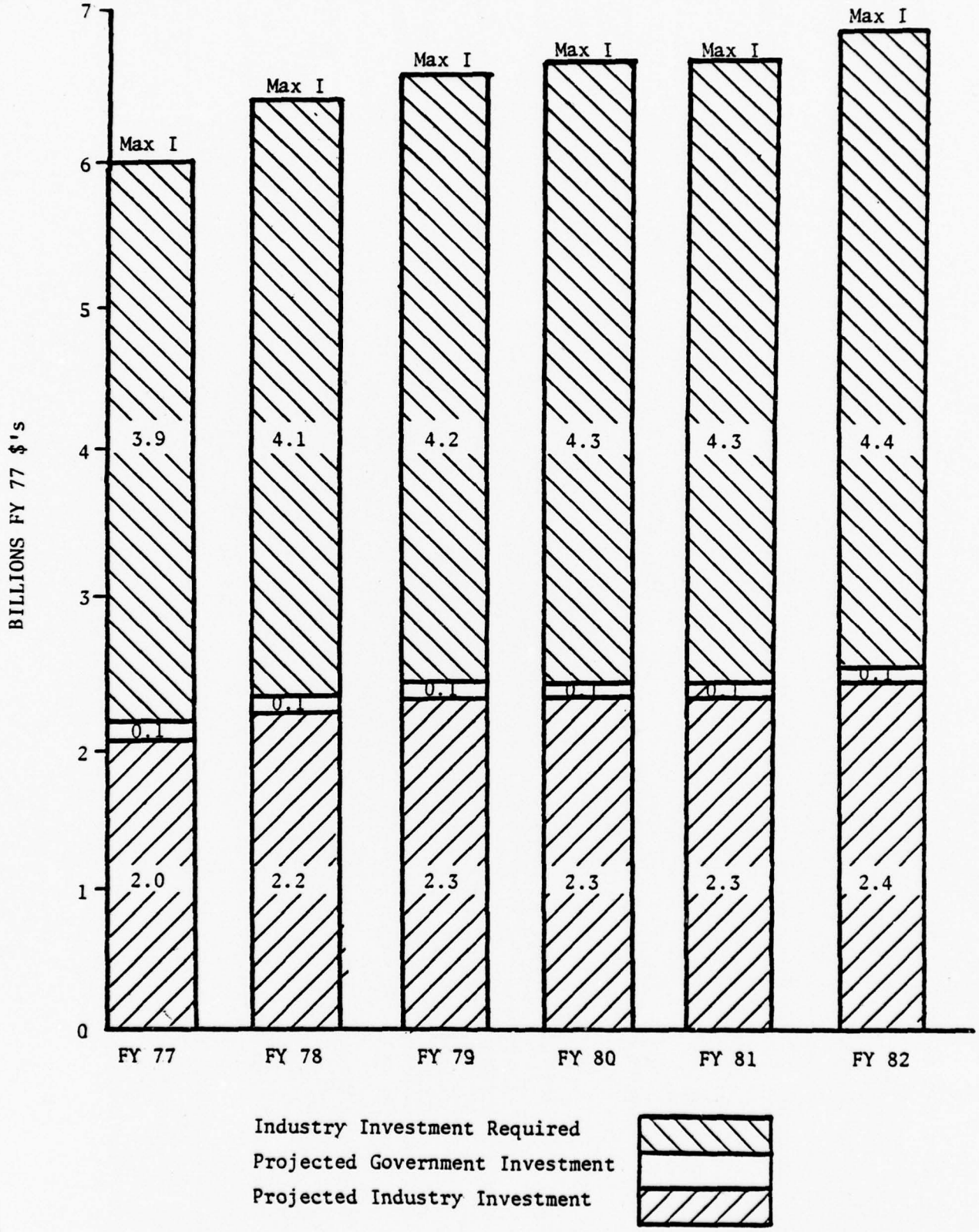
[1]Total of DoD hardware procurements, O&M spares, and FMS.

[2]Total capital required for defense business investment if defense sector invests at same rate (% of new annual investment to sales) as commercial sector did from 1970–1974.

[3]Total capital required by defense industry for defense business investment if defense sector invests at 1970-1974 defense sector rate (% of new annual investment to sales). Assumes Government investment at a continued rate of $100 million annually.

[4]Difference between [2] and [3]. Assumes Government investment at a level rate of approximately $100 million annually.

FIGURE A-1. POTENTIAL AND PROJECTED DEFENSE BUSINESS INVESTMENT INCLUDING LEASES
(Billions FY 1977 Dollars)



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APPENDIX B

PRESENT VALUE (DISCOUNTED) CASH FLOW ANALYSIS OF CAPITAL INVESTMENT

1. Introduction

In the most general sense, capital investment means deferring the immediate use of resources in favor of expected future benefits. For the profit-seeking firm,

> a capital expenditure is one in which the company's funds are committed for projects which will return the invested funds and profits during future periods.[1]

Investment can apply to the purchase of fixed plant and equipment used for the production of goods and services; it can consist of inventories of materials which are finally consumed in the production process; it can represent an increase in the stock of human knowledge; or it can take the form of processes, like research or marketing campaigns, which result in future benefits to the firm.

Since the subject of this report is cost-saving investments by defense firms, Appendix B is limited to investment in fixed plant and equipment. This type of investment comprises expenditures and benefits that, for the most part, are expressible in dollar values. Preliminary to presenting examples of the present value method of anlysis, compounding and discounting formulas are first examined.

2. Interest Formulas

(a) Compound Value

Disregarding taxes, liquidity, uncertainty and other investment considerations, suppose a firm deposits (invests) $1000 in a savings bank account for three years at a 5% compound annual interest rate. This action indicates the firm is willing to accept $1157.63 from the bank at the end of the third year, in place of using the $1000 at the beginning of the first year. The calculations are shown in Table B–1.

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[1] Barish, Norman N., Economic Analysis, N.Y., McGraw-Hill, 1962, p. 185

TABLE B-1. COMPOUND INTEREST[1]

Year	Principal Amount at Beginning of Year (a)	Interest Earned During Year at 5% (b)	Total Amount at End of Year (c) = (a)+(b)
1	$1000.00	$1000.00(.05) = $50.00	$1050.00
2	$1050.00	$1050.00(.05) = $52.50	$1102.50
3	$1102.50	$1102.50(.05) = $55.13	$1157.63

[1]Barish, p.50.

If

P = Sum of money at time designated as the present (end of period 0)

i = Interest rate per interest period

T = Number of interest periods

S_T = Future sum (at end of period T) which is equivalent to present sum P,

then

$$S_1 = P + iP = P(1+i)$$

$$S_2 = S_1 + iS_1 = S_1(1+i) = P(1+i)(1+i) = P(1+i)^2$$

.

.

.

1) $$S_T = P(1+i)^T.$$

For the example of Table 1 ($P = \$1000$, $i = 0.05$, and $T = 3$),

$$S_3 = 1000(1+0.05)^3 = 1000(1.15763) = \$1157.63.$$

The ratio

2) $$S_T/P = (1+i)^T$$

is called the Single-Payment Compound-Amount Factor.[2]

[2]This factor and others are found tabulated for various values of interest rates, i, and periods, T, in Barish, pages 695-712.

(b) Present Value

Expression 1) permits the firm to calculate the future value, S_T, of the present sum, P. Dividing both sides by the factor allows the derivation of the present value P of the payment of the future value, S_T

3) $P = S_T/(1+i)^T$.

The ratio

4) $P/S_T = 1/(1+i)^T$

is called the Single-Payment Present-Worth Factor.

If the firm wanted \$1157.63 from the bank after three years, it would be required to deposit \$1000 at the end of year zero (beginning of year one):

$P = 1157.63/(1+0.05)^3 = 1157.63/1.15763 = \$1000.$

If the firm wanted \$1000 at the end of three years, it would be required to deposit \$863.83 at the beginning of year one:

$P = 1000/1.15763 = \$863.83.$

As will be illustrated later, Expression 3) is the key formula for use in present value analysis. Before explaining the analysis, a few additional investment formulas will be presented.

(c) Compound Amount in Fund[3]

Assume a constant amount of R dollars is deposited at the end of each period, and S_T is the sum of the compounded values of the R's at the end of the Tth period, i.e.,

5) $S_T = R(1+i)^{T-1} + R(1+i)^{T-2} + \ldots + R(1+i)^{T-(T-1)} + R.$

The future value (at the end of period T) of R dollars deposited at the end of the first period is (from 1)) $R(1+i)^{T-1}$, since there are T-1 periods remaining. The future value of the R dollars deposited at the end of the second period equals $R(1+i)^{T-2}$, and so on. The

[3]Barish, p. 52.

future value of the R dollars deposited at the end of the Tth period is R (it does not draw interest).

A simplified version of 5) is obtained by multiplying both sides of 5) by (1+i) and then subtracting 5) from the new expression to obtain

$$(1+i)S_T - S_T = R(\ (1+i)^T + \ldots + (1+i)\ )$$
$$- R(\ (1+i)^{T-1} + \ldots + 1\ )$$
$$iS_T = R(\ (1+i)^T - 1\ )$$

6) $$S_T = R(\ (1+i)^T - 1\ )/i.$$

If the firm makes a \$1000 deposit at the end of year one through year ten, and receives interest at the rate of 5% annually, at the end of the tenth year it could withdraw, using 6):

$$S_{10} = 1000(\ (1+0.05)^{10} - 1)/0.05$$
$$= 1000(12.578) = \$12{,}578.$$

The ratio,

7) $$S_T/R = (\ (1+i)^T - 1)/i,$$

is called the Uniform-Series Compound-Amount Factor.

If the relationships (of P, S_T, R, i and T) described by Expressions 2) and 6) are known, three additional investment factors can be easily determined. They are: the Sinking-Fund-Payment Factor, the Capital-Recovery Factor, and the Uniform-Series Present-Worth Factor.

(d) Sinking Fund Deposit

Dividing both sides of 6) by the factor of 7) gives

8) $$R = S_T\ (i/(\ (1+i)^T - 1)\ ).$$

If the firm wished to build a "sinking fund" equal to \$12,578 by the end of year ten, it could deposit (at 5% interest),

$R = 12578(1/12.578) = \$1000$ per year at the end of each year. The ratio,

9) $$R/S_T = i/(\ (1+i)^T - 1),$$

is the reciprocal of 7) and is called the Sinking-Fund-Payment Factor.

(e) Capital Recovery

Substituting S_T of 1) into 8) determines

10) $R = P\ (i(1+i)^T)\ /\ (\ (1+i)^T - 1)$.

Suppose the firm borrows \$10,000 from the bank and agrees to repay the principal over ten years, including interest at 5% on all unpaid balances, in uniform annual payments, R. The amount the firm must pay the bank at the end of years 1, 2, ... 10 is calculated using 10):

$$R = 10000\ (.05(1+.05)^{10})\ /\ (\ (1+0.05)^{10} - 1)$$

$$10000\ (0.12950) = \$1295 \text{ per year.}$$

The ratio,

11) $R/P = (i(1+i)^T)\ /\ (\ (1+i)^T - 1)$,

is called the Capital-Recovery Factor. If the firm had used the \$10,000 loan to purchase productive equipment, it is obvious that the equipment should generate <u>at least</u> \$1295 net each year for repayment of the loan.

(f) Present Value of a Uniform Series

Rearranging expression 10) by dividing both sides by the factor of 11) provides the formula for the present value of a uniform series:

12) $P = R\ (\ (1+i)^T - 1)\ /\ (\ i(1+i)^T)$.

Referring to the previous example, suppose the firm is considering the purchase of equipment estimated to generate \$1295 net at the end of each year for a ten-year period. If the firm intends to borrow the money from the bank and repay the loan in ten equal installments at a 5% interest rate, the maximum amount it could afford to pay for the equipment (at the end of year 0) is:

$$P = 1295(1/0.1295) = \$10,000.$$

The ratio,

13) $P/R = (\ (1+i)^T - 1)\ /\ (i(1+i)^T)$,

is the reciprocal of 11) and is called the Uniform-Series Present-Worth Factor. This

factor is also called "payback" or "payout," as it represents the time required to recover the capital investment out of the earnings or savings.[4]

(g) Summary of Interest Formulas

Table B–2 summarizes the interest factors discussed above for interest rates of 5% and 10%, and for periods of 1, 10, and 20 years. The pairs of factors S/P and P/S, S/R and R/S, and R/P and P/R are reciprocals.

As an illustration of the relationship of the formulas, consider the uniform series example of the preceeding sub-section,

R = \$1295 per year, i = 0.05, T = 10 years.

From expression 12) (and the P/R factor of Table B-2), the present value (at the end of year 0) of this uniform series is:

P = 1295(7.722) = \$10,000.

The value of the compound sum of the stream at the end of year 10 is determined using expression 6) (and the S/R factor of Table B–2):

S_{10} = 1295(12.578) = \$16,289.

The present value (at the end of year 0) of the sum \$16,289 at the end of year 10 is determined using expression 3) (and the factor P/S of Table B–2):

P = 16,289(0.6139) = \$10,000.

If the firm's time value of capital (interest rate) is 5% per year, the above analysis illustrates the equivalency of \$10,000 now, a ten year uniform stream of \$1295 per year, and \$16,289 at the end of the tenth year.

3. Investment Analysis

Investment analysis is too extensive a subject for a short appendix. In this section, two types of capital investment analyses are illustrated: 1) Total life-cycle discounted cash flow, and 2) Incremental life-cycle discounted cash flow. In 1), the

[4]Barish, p. 233.

TABLE B-2. INTEREST FACTORS[1]

Factor Expression	S/P 2)	P/S 4)	S/R 7)	R/S 9)	R/P 11)	P/R 13)
			5% Interest Rate			
Period T						
1	1.050	0.9524	1.000	1.0000	1.0500	0.952
.						
.						
.						
10	1.629	0.6139	12.578	0.0795	0.1295	7.722
.						
.						
.						
20	2.653	0.3769	33.066	0.0302	0.0802	12.462
			10% Interest Rate			
1	1.100	0.9091	1.000	1.0000	1.1000	0.909
.						
.						
.						
10	2.594	0.3855	15.937	0.0628	0.1628	6.144
.						
.						
.						
20	6.727	0.1486	57.275	0.0175	0.1175	8.514

[1]Source: Barish, pp. 690 and 693.

investment is assumed to be associated with a new, independent production process that does not replace an existing process. In 2), the investment is assumed to replace existing equipment, but perform the same process.

To obtain background on the analyses, the reader may refer to Department of Defense Instruction 7041.3, "Economic Analysis and Program Evaluation for Resource Management," October 18, 1972. Enclosures 2 and 3 of the Instruction are important. Barish and Terbough[5] are also useful.

[5]Terbough, George, Business Investment Management, Machinery and Allied Products Institute and Council for Technological Advancement, Washington, D. C., 1967.

(a) Example of Total Life Cycle Discounted Cash Flow Analysis

Table B–3 presents tabulated calculated data associated with the present value analysis of a hypothetical investment. Several assumptions are made.

It is assumed that the installed cost of the asset at the end of year 0 is one million dollars.[6] The economic or service life of the asset and the tax life are assumed to be eight years.[7] For tax purposes, depreciation is calculated using the straight-line method.[8] The firm's income tax rate is 48%. The firm sells the asset at the end of the economic life (year eight), and receives a net after-tax addition of $100,000 to its cash flow.

The estimates of the time streams of the operating revenues and costs (shown in rows d) and e)) are assumed to be known with certainty. That is, the variances of the forecasted revenues and costs are zero. (The values of these time streams were selected to reflect typical effects of startup problems, learning curve efficiencies, declining quality and market effectiveness, and increased maintenance and other upkeep costs as the asset ages.)

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[6]The installed cost of the asset includes the purchase or construction cost, delivery costs, installation costs and other costs necessary to get the asset into operation. (See DoDI 7041.3, Encl. 2, p. 2.)

[7]The economic life or service life of an asset is the length of operating time that, for a required rate of return, maximizes the present value of the investment. The economic life differs from the physical or the tax life of the investment. (See Bowman and Fetter, Analysis for Production and Operations Management, Richard D. Irwin, Homewood, Ill., 1967, or Terbough.)

[8]Methods of Calculating Depreciation: There are three major methods used by firms in the calculation of (tax) depreciation charges: Straight-Line, Double-Declining-Balance and Sum-of-Digits. The latter two are called declining-charge-depreciation methods. If the depreciation life of the asset is n years and y (y=n, n-1, . . . 1) represents the number of depreciation years remaining, the rates of depreciation on the undepreciated balance are:

Straight-line: 1/y
Double-Declining-Blanace: 2/y
Sum-of-Digits: 2/(y+1)

Table B-4 illustrates the calculation of the depreciation of an asset which costs $1000, has a ten-year tax life, and no salvage or terminal value at the end of the ten-year period.

TABLE B-3. TOTAL LIFE CYCLE DISCOUNTED CASH FLOW ANALYSIS
(Constant Thousands of $)

	Calendar Year	0	1	2	3	4	5	6	7	8
(a)	Investment (Dec. 31)	1000								
(b)	Book Value (Jan. 1)		1000	875	750	625	500	375	250	125
(c)	Depreciation (St. Line)		125	125	125	125	125	125	125	125
(d)	Operating Revenue		700	750	800	800	800	750	700	650
(e)	Operating Costs		400	350	300	300	300	350	400	450
(f)	Taxable Earnings ((d) - (e) - (c))		175	275	375	375	375	275	175	75
(g)	Earnings After Tax (0.52(f))		91	143	195	195	195	143	91	39
(h)	Inv. Terminal Value After Tax									100
(i)	Cash Flow ((g) + (c) + (h))		216	268	320	320	320	268	216	264
(j)	Cumulative Cash Flow		216	484	804	1124	1444	1712	1928	2192
(k)	Discount Factor (P/S @ 10%)		0.909	0.826	0.751	0.683	0.621	0.565	0.513	0.467
(l)	Present Value (at 10% ((k) x (i))	$\sum_{1}^{8}$ =1460	196	221	240	219	199	151	111	123
(m)	Discount Factor (P/S @ 20%)		0.833	0.694	0.579	0.482	0.402	0.335	0.279	0.233
(n)	Present Value (at 20% ((m) x (i))	$\sum_{1}^{8}$ =1046	180	186	185	154	129	90	60	62

TABLE B-4. EXAMPLES OF DEPRECIATION METHODS[1]

Year	Years Remain.	Straight Line		Double Declining		Sum-of-Digits	
		Beginning Balance	Depreciation Charge	Beginning Balance	Depreciation Charge	Beginning Balance	Depreciation Charge
			(1/y) (Bal.)		(2/y) (Bal.)		(2/(y+1))(Bal.)
1	10	1,000	100	1,000	200	1,000	182
2	9	900	100	800	178	818	164
3	8	800	100	622	156	654	145
.							
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.							

[1]Sources: Terbough p.147, Gordon, Myron J., and Schillinglaw, Gordon, Accounting: A Management Approach, Richard D. Irwin, Homewood, Ill., 1964.

Another important aspect of the problem not considered is the impact of price changes over the time horizon on the investment cost, the operating revenues, and the operating costs. (See DoDI 7041.3, Enc. 2, page 8 for remarks on the Treatment of Inflation.)

The cash flow values of row (i) represent on-hand funds available to the firm for reinvestment, retirement of debt or distribution to stockholders.

> The profitability of an investment is dependent upon the cash flow: *the amount and timing of the cash income and cash costs* produced by the investment.[9]

The present value of the cash flow of the investment is $1,460,000 at the 10% discount rate and $1,046,000 at the 20% discount rate (rows (1) and (n), respectively). The net present value of the cash flow (after subtracting the cost of the investment) is $460,000 at the 10% rate and $46,000 at the 20% discount rate.

The internal rate of return (IRR) is the discount rate which equates the present value of the cash flow with the cost of the investment.

$$C = \sum_{t=1}^{N} R_t/(1+r)^t \text{ where}$$

C : Investment cost

R_t = Cash flow in period t

N : Number of time periods considered

r : Required rate (IRR) to satisfy the equation.

Using linear interpolation, the IRR for the example is 21.1% per year. That is, if the cash flow row (i) were discounted at 21.1% per year, the sum would equal $1,000,000.[10]

The payback period is the number of periods required for the (undiscounted) cumulative cash flow (row (j)) to have the same value as the investment

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[9] Barish, p. 47

[10] $\frac{IRR - 0.20}{1000 - 1046} = \frac{0.20 - 0.10}{1046 - 1460}$, IRR = 0.211

cost. Through linear interpolation, cumulative cash flow equals $1,000,000 in 3.6 years. The payback period is 3.6 years.

(b) Example of Incremental Life-Cycle Discounted Cash Flow Analysis

Table B–5 presents tabulated calculated data of an alternative investment case taken from the General Dynamics F-16 Facility Plan. (See II–51 through 70.) The equipment in this case is 5 axis-3 spindle profile mills with an installed cost of $1,861,000. It replaces the existing method of production. The gross yearly savings over the present method of operation are estimated to be $894,000. There are no terminal savings included from selling the existing equipment or the new equipment. Row (c) represents the depreciation schedule used by General Dynamics for this type of equipment. It is assumed that operations do not start until the second half of the first year. The other assumptions stated in the preceeding example also apply. The analysis applies to commercial contract conditions.

The present value of the cash flow of the investment is $2,907,000 at the 10% discount rate and $2,080,000 at the 20% discount rate (rows (j) and (l), respectively). The net present value of the cash flow (after subtracting the cost of the investment) is $1,091,000 at the 10% rate and $264,000 at the 20% discount rate. The internal rate of return (IRR) is 24.7%. This is the discount rate which makes the sum of the discounted cash flow equal to the $1,816,000 cost of investment.[11] From linear interpolation of the cumulative cash flow values (row (h)) the payback period is calculated as 3.3 years.

4. Investment Decision Criteria

The preceeding discussion introduced the concepts of net present value, internal rate of return, and payback period. Table B–6, reproduced from a paper by Hax and Wiig, briefly summarizes these concepts (plus the unadjusted rate of return method) and points out the advantages and disadvantages of these measures as criteria for investment decisions.

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[11] $\frac{IRR - 0.20}{1816 - 2080} = \frac{0.20 - 0.10}{2080 - 2907}$, IRR = 0.247

TABLE B-5. INCREMENTAL LIFE CYCLE DISCOUNTED CASH FLOW ANALYSIS
(Constant Thousands of $)

	Calendar Year	0	1	2	3	4	5	6	7	8
(a)	Investment (Dec. 31)	1816								
(b)	Book Value (Jan. 1)		1816	1557	1112	772	494	278	124	31
(c)	Depreciation (Declining Balance)*		259	445	340	278	216	154	93	31
(d)	Gross Savings		447	894	894	894	894	894	894	894
(e)	Taxable Program Savings ((d)-(c))		188	449	554	616	678	740	801	863
(f)	Earnings After Tax (0.52(e))		98	233	288	320	352	385	417	445
(g)	Cash Flow ((f)+(c))		357	678	628	598	568	539	510	476
(h)	Cumulative Cash Flow		357	1035	1663	2261	2829	3368	3878	4354
(i)	Discount Factor (P/S @ 10%)		0.909	0.826	0.751	0.683	0.621	0.565	0.513	0.467
(j)	Present Value (@ 10%)((i)x(g))	$\sum_{1}^{8}$ =2907	325	560	472	408	353	305	262	222
(k)	Discount Factor (P/S @ 20%)		0.833	0.694	0.579	0.482	0.402	0.335	0.279	0.233
(l)	Present Value (@ 20%)((k)x(g))	$\sum_{1}^{8}$ =2080	297	470	364	288	228	181	142	110

*Mixture of DDB and SYD used by firm.

TABLE B-6. SUMMARY OF INVESTMENT PROFITABILITY MEASURES[1]

Method	Definition	Computation	Advantages	Disadvantages
Payback Period	Number of years until investment is recouped	If rate of flow is constant $\text{Payback} = \frac{\text{Investment}}{\text{Net Cash Flow}}$; otherwise, the payback is determined by adding up the expected cash inflows until the total equals the initial investment	1. Simple to use and understand 2. Makes allowances for for risk attitudes 3. Commonly known and used 4. Useful as a constraint	1. Ignores cash flow beyond payback period 2. Ignores timing within payback period 3. Overemphasizes liquidity as investment criterion
Accounting (or Unadjusted) Rate of Return	Ratio of average annual income after depreciation to the average book value of the investment	$\frac{\text{Average Annual Cash Inflow} - \text{Average Annual Depreciation}}{\frac{1}{2}\text{ Initial Investment}}$	1. Easy to compute and understand 2. Commonly known and used	Ignores timing of cash flows
Net Present Value (NPV)	Difference between cash inflows and outflows discounted to the present at a given interest rate	$NPV = \sum_{t-1}^{T} \frac{F_t}{(1+i)^t}$ where F_t=net cash flow at time period t i =discount rate T=planning horizon	1. Takes time value of money into account 2. Easier to compute than ROI	1. Requires definition of a discount rate 2. Less intuitive than ROI
ROI (Rate of Return of the Investment, or Internal Rate of Return)	Discount rate which makes the net present value of inflows and outflows equal to zero	The ROI is determined by solving the equation $\sum_{t=1}^{T} \frac{F_t}{(1+i)^t} = 0$ where i is the rate of the investment	1. Takes time value of money into account 2. Does not require definition of a cutoff rate 3. Intuitively appealing	1. Computationally complex (requires trial and error) 2. Assumes other investment opportunities exist at same ROI 3. Does not consider size of scale of the investment 4. Occasionally provides more than one discount rate, or none

[1]Source: Hax, A. C., and Wiig, K. M., "The Use of Decision Analysis in Capital Investment Problems," Sloan Management Review, Winter 1976, Vol. 17, No. 2, pp. 26-27

Table B–7 is taken from a 1974 study by P. J. Davey on the investment analysis procedures of 136 U. S. companies. The table presents the frequency of usage of various investment decision criteria by the firms.

Generally, the evaluation of investment proposals through use of the investment criteria consitutes only a preliminary (screening) stage of the overall procedure. Davey adds,

> Further studies are made before decisions are reached on capital investment outlays. These extra reviews consist of attempts to deal with the risks and uncertainties contained in the results forecast for various proposals by financial analysis.[12]

The goal is to determine the capital budget of ranked investment opportunities that maximizes the benefits generated by the investments and satisfies the capital constraints confronted by the firm. The ranking of the investment opportunities into an investment schedule ultimately depends upon management judgment concerning investment priorities.

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[12] Davey, P. J., Capital Investments: Appraisals and Limits, Technical Report No. 641. The Conference Board, N.Y., N.Y., 1974, p. 11.

TABLE B-7. MATHEMATICAL CRITERIA USED IN CAPITAL EXPENDITURE ANALYSIS[1]

Criteria	Number of Mentions as Exclusive Yardstick	Number of Mentions as One of Several Yardsticks	Budget Categories[2] of Using Respondents					
			I	II	III	IV	V	VI
Payback	19	80	26	35	14	11	8	5
Discounted cash flow rate of return	20	68	18	34	10	11	10	5
Return on Investment	3	31	4	17	3	4	4	2
Net present value	1	30	2	13	4	4	4	4
Benefit-cost ratio (profitability index)	1	11	5	3	2	1	1	-
Discounted payback	-	2	-	2	-	-	-	-
Present value of minimum revenue requirements	-	1	-	-	-	-	1	-
Present worth of annual charge cost study techniques	1	-	-	-	-	-	-	1
Effect on reported earnings	-	1	-	-	1	-	-	-
MAPI	-	1	-	1	-	-	-	-
Lowest bidder	1	-	1	-	-	-	-	-
Undiscounted total profit	-	1	-	-	-	1	-	-
Total	46	226	56	105	34	32	28	17

[1]Source: Davey, P. J., Capital Investments: Appraisals and Limits, Technical Report No. 641. The Conference Board, N.Y., N.Y., 1974, p. 8.

[2]Budget Categories
I - Less than $10 million
II - $10 to $49 million
III - $50 to $99 million
IV - $100 to $199 million
V - $200 to $499 million
VI - $500 million and higher

APPENDIX C

SOURCES OF CAPITAL

In the capital budgeting process, a firm's top management must project the supply of money for capital investments and its interaction with the firm's total capital structure. The focus of this appendix is the sources of capital available to manufacturing firms in general, and defense industry firms in particular. Private sector sources of capital will be discussed first, followed by a brief discussion of Government sources of capital.

1. Private Sector Sources of Investment Capital

Private sector sources of capital can be divided into two categories: internal and external. Internal sources are chiefly depreciation and retained earnings. They also include sale of assets and the investment tax credits. External sources are debt or equity issues sold publicly or privately to outside parties.

Depreciation charges are accounting entries that can be regarded as a source of capital because, as assets decline in value, the firm's tax liability is reduced. However, with the high level of inflation in recent years, the depreciation charges allowed by the tax laws have been insufficient to minimize the impact of depreciated replacement costs. The firm, therefore, cannot rely solely on depreciation charges to maintain its capital stock. Additional sources of capital must be used, or its assets will be liquidated over time.

Retained earnings are another source of internally-generated capital. Retained earnings are the funds available after dividends have been distributed. The greater the percentage paid in dividends, the lesser the retained earnings available for reinvestment. Many new firms pay no dividends for a number of years during their early fast growth periods. As the firm matures, the internal rate of reinvestment generally declines, resulting in a greater payout of earnings in the form of dividends.

Other internal sources of capital include the after-tax proceeds from the sale of a capital asset. Equipment that is being replaced is frequently sold. The salvage value is the selling price of the equipment, less the seller's cost of removal and delivery. Additionally, a firm may decide to sell a plant or an entire division. Such sales are a one-time source of capital for reinvestment in new production equipment.

Lastly, the investment tax credit (ITC) currently allows a firm to reduce its first year corporate tax liability by 10% of the acquisition value of a capital investment. However, the cost of capital has recently exceeded the ITC, and caused some firms to postpone investments.

The major external sources of capital are proceeds from the sale of equity and debt to outside parties. Equity or stock represents ownership in the firm; debt is merely a contractual lending arrangement.

Equity issues may take several forms, depending upon the articles of incorporation and the existing capital structure of the firm. Common stock is usually voting stock, but its rights to sharing in the profits and liquidation proceeds are superseded by all other obligations of the firm. Preferred stock generally is non-voting, but has preference over common stock when dividends are distributed. Some preferred stock may be convertible into common stock or corporate bonds.

There are also several sources of short and long-term debt. Historically, the basic financing instruments for corporations have been the unsecured line of credit and the term loan from a commercial bank. The term loan was generally used for long-term capital needs, while the line of credit was used to alleviate temporary shortfalls in a firm's cash flow. Today, almost all such lending to corporations is arranged on a short-term but renewable basis, with the interest rate adjusted periodically for changes in the prime rate.

Corporations also obtain long-term debt financing from insurance companies. Most of this financing is through private placements of debt issues with 15 or more years'

maturity. Long-term loans represent investments that match the requirements of their future actuarial liabilities. Corporations use these loans primarily for funding fixed investment programs.

Another method of securing debt financing is through the sale of notes or bonds in the open market. Corporations can sell short-term obligations in the commercial paper market to meet temporary cash needs. These obligations generally have maturities from overnight to one year. Corporations can likewise sell long-term debt, usually through an investment banker.

A firm can defer capital investments by availing itself of capital assets owned by others. If the firm is unwilling to purchase certain capital assets, it may rent or lease them. The firm uses the leased equipment in its production process, and revenues generated by the operation of the equipment accrue to the firm. The lease payments for the equipment cover the owner's capital investment depreciation, profit, plus other costs. The advantages to the lessee are use of the equipment for the time needed, however brief, as well as the flexibility to upgrade his assets as technological advances are made. Alternatively, the firm can decide to buy a product from a vendor or subcontractor, instead of investing in the capital assets necessary to produce the product.

2. U. S. Government Sources of Capital

The defense industry receives most of its financing for investments in long-term assets from the same sources as non-defense firms. There are, however, provisions in the Armed Services Procurement Regulations (ASPR) that affect the contractors' long-term capital needs. DoD's currently stated policy is that defense firms should decrease their reliance on the Government as a source for long-term assets. However, for specific contractors and certain weapons systems, the following sources of Government financing are important.

In some cases, Government-owned facilities—plant and equipment (GOF)—are provided to contractors for use in a specific contract. Since most defense contracts are

price negotiated, based on costs, all benefits (including cost savings) associated with the use of the GOF theoretically accrue to the DoD. The DoD does not charge the contractor rent for the equipment if less than 25% of the total operating time is logged against commercial work. The use of GOF allows the contractor to use his capital for investment in other, often non-defense related assets.

In some situations, the contractors must purchase equipment for which they have no use after fulfilling a specific Government contract. In these cases, the contractor is usually allowed to purchase the equipment, and charge it off as an allowable cost over the life of the contract. At the end of the contract, the equipment becomes the property of the DoD.

As described in the ASPR, the normal methods of contract financing are guaranteed loans, advance payments, and progress payments. These methods reduce the firm's demands on commercial sources for its working capital.

> Guaranteed Loans—usually called "V-loans," are essentially the same as other loans made by financing institutions without guarantee, except that under a standard form of guarantee agreement the guaranteeing agency is obligated on demand of the lender to purchase a stated percentage of the loan and to share losses in the amount of the guaranteed percentage. Guaranteed loans afford an especially convenient medium for financing borrowers who hold subcontracts, or numerous prime contracts, or prime contracts with several contracting agencies. Funds are disbursed and collected by the lending institution, and its personnel administer the loan. Government funds are not involved except for purchases of the guaranteed portion of loans or settlement or losses.[1]
>
> Advance Payments—are advances of money, made by the Government to a contractor prior to, in anticipation of, and for the purpose of complete performance under a contract or contracts. Advance payments are made only to prime contractors. They are expected to be liquidated from payments due to the contractor incident to performance of contracts. Since they are not measured by performance, they differ from partial, progress, or other payments made because of and on the basis of performance or part performance of a contract. Advance payments may be made to prime contractors for the purpose of making subadvances to subcontractors.[2]

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[1] ASPR, 1 July 1976, Appendix E, Page E:2.

[2] Ibid.

Progress Payments--The term "progress payments," as used herein, signifies payments made as work progresses under a contract, upon the basis of costs incurred, of percentage of completion accomplished, or of a particular stage of completion. As used in these regulations this term does not include payments for partial deliveries accepted by the Government under a contract, or partial payments on contract termination claims.[3]

The recent high rates of inflation experienced by the economy have led to the increased use of economic price adjustments (EPA) in DoD long-term fixed-price contracts. The EPA payments compensate the contractor for abnormal increases in the labor and material costs resulting from general economic trends.

[3]Ibid, page E:3.

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APPENDIX D

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Defense Industrial Base, Procurement Policy Analysis, DPC 76-3, Award Fee, Rapid Depreciation, Cost Reducing Investment, Motivating Factors, Terminating Guarantees, Shared Savings, Productivity Growth, Multi-year Contracting, CAS 409, Investment Incentives, Capital Investment Opportunities, Case Studies, MACRO-Economic, Investment Projections.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report examines current investment opportunities for defense-related industries and the factors motivating capital investment, especially those related to cost reduction. Changes to, or broader applications of, DoD procurement policy that would motivate defense-related industries to make such cost-reducing investment are recommended. The report contains capital investment case studies of four industries and a macroeconomic projection of defense industries' capital investment requirements.

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