FEDERAL INCENTIVES FOR INDUSTRIAL MODERNIZATION: HISTORICAL REVIEW AND FUTURE OPPORTUNITIES

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N89-25764

(NASA-TM-101785) FEDERAL INCENTIVES FOR INDUSTRIAL MODERNIZATION: HISTORICAL REVIEW AND FUTURE OPPORTUNITIES (NASA. Marshall Space Flight Center) 37 p CSCL 05A

Unclas G3/81 0213097

August 1987

Prepared for Submission to the IIE Journal

The Engineering Economist

ABSTRACT

Concerns over the aging of the U.S. aerospace industrial base led DOD to introduce first its Technology Modernization (Tech Mod) Program, and more recently the Industrial Modernization Incentive Program (IMIP). These incentives include productivity shared savings rewards, contractor investment protection to allow for amortization of plant and equipment, and subcontractor/vendor participation. The purpose of this paper is to review DOD IMIP and to evaluate whether a similar program is feasible for NASA and other non-DOD agencies. The IMIP methodology is of interest to industrial engineers because it provides a structured, disciplined approach to identifying productivity improvement opportunities and documenting their expected benefit. However, it is shown that more research on predicting and validating cost avoidance is needed.

LIST OF FIGURES

I. INTRODUCTION

Industrial productivity has been defined as the ratio of valuable output to input, i.e., the efficiency and effectiveness with which resources -- personnel, machines, materials, facilities, capital and time -- are utilized to produce a valuable output [10]. A recent article [21] in Industrial Engineering cites that high among the reasons for lagging productivity in the U.S. are outdated, outmoded production methods being used in places where capital investment has been minimal. Almost 70% of equipment used in aerospace production is more than twenty years old [21]. The aerospace industrial base as utilized by the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA) functions under a variety of inherent difficulties which impede productivity gains: (1) complexity of the product; (2) relatively low build rates; (3) frequent changes in the basic product; and (4) substantial use of exotic materials and specialized subsystems, components, and parts. These difficulties are further exacerbated by exterior forces on the government contractor by such things as (1) production re-scheduling and stretch-outs, (2) funding availabilities, (3) short-term contracting and financing, and (4) economic and environmental regulations.

To modernize a plant and improve productivity, the industrial engineer must ensure effective use of resources, integrate a unified and efficient effort, provide a baseline for performance evaluation, and prepare for future opportunities and risks. This planning must encompass long range markets and rate of growth, medium range demand for product and capital facilities and short range sales, personnel space needs, and cash flow. Major capital investments must be planned, designed, and installed in advance of need. Too often the decision on investment has been delayed for profit reasons of using the available but worn-out or unproductive capital equipment or facilities. Often in the aerospace industry, these facilities are government-owned.

DOD capital expenditures to improve defense industry productivity growth are described in [2] by "policy solutions to incentivize corporate capital investments have been promulgated in two specific areas: (1) changes to contractual policies relative to negotiated profit objectives and progress payment rates to increase the cash flow of defense contractors; and (2) the provision of government "seed money" as direct performance incentive payments to specific contractors to bring high technology industrial modernization to the factory floor." Early efforts in this area by the U.S. Air Force were called Tech Mod (technology modernization). This concept matured into the DOD's Industrial Modernization Incentive Program (IMIP), authorized on 2 November 1982 and referred to as "the cornerstone of DOD efforts to improve defense contractor productivity [12]." The GAO has published an extensive review of DOD Manufacturing Technology programs that preceded IMIP [8], in fact 132 projects were selected for detailed review. The purpose of this paper is to review IMIP as a DOD-funded program of quite recent origin and evaluate whether a similar program can be used by NASA and other non-DOD agencies.

Historically, NASA and other non-DOD agencies have incentivized cost reduction through contracting modes that led to various rewards and sharing of cost-savings, based on performance. For this reason, a review of Federal government procurement practices is provided in Section II. The DOD now has a track-record in applying IMIP, which we describe in Section III. In Section IV the feasibility of discrete application of a formal Industrial Modernization Incentive Program (IMIP) on non-defense Federal government-funded prime and subcontractors projects will be assessed. The decision factors for implementation of IMIP will be identified and applied in an example. NASA IMIP explorations will be reviewed.

II. GOVERNMENT PROCUREMENT PRACTICES

Government contacts are of two forms: (1) completion-end-product delivery in a specific time, and (2) term-specified effort over designated time. The form of contract used reflects the contractor's legal obligation, or lack of obligation to deliver specified end-products. "If specified work under a cost-reimbursement contract is not completed by the contractor within estimated cost, the contractor is nonetheless obligated to continue his efforts to complete the work as long as the government is willing to fund the additional efforts [15]." Under a fixed-price completion arrangement, any funding required beyond the ceiling price rests entirely on the contractor.

Term contracts are often used in early R&D efforts where technical outcomes are difficult to forecast and assurance of success is lacking.

Irrespective of actual accomplishment, the specified delivery of the level-of-effort completes the contract. Under term contracts, the government bears the risk of the contractor not wishing to continue; while under the completion form, the contractor must continue work till it is deemed "complete." These two forms are often called "mission" type and "best-efforts" type. Risk assessment and guidelines for profit/fee motivation are factors associated with determination of proper contracting form.

The two family groups of contracts are (1) cost reimbursement and (2) fixed price. In cost reimbursement, the government must pay all allowable, allocable, and reasonable costs including any overruns or growth. The government's procurement regulations stipulate the measures of cost allowability, allocability, and reasonableness. These cost type contracts allow the government great flexibility in contract direction within the contracts scope of work (SOW). This flexibility equates to additional cost to government and less risk to the contractor.

Fixed-price contracts establish a firm fixed price (ceiling) beyond which it is legally impossible to fund cost overruns or growth. Conversely, if the contractor underruns his cost estimates he pockets all the savings. Thus, a strong cost incentive is placed on the contractor and less on quality or on-time deliveries. Therefore, the fixed price contract are considered for procurements where design is firm, cost estimates are reliably certain, and schedules are easily attainable.

A. <u>Contractor Risk</u>

The two families (cost and fixed price) of contracts are further divided into specific types of contracts which delineate the government's responsibility to pay the costs incurred by the contractor. At one end of the responsibility/risk spectrum is the firm fixed price which provides a ceiling price that is not subject to adjustment for actual cost variances experienced by the contractor. At the other end the contractor's fee (profit) is a fixed amount and costs are reimbursed at actual. Within these extremes, the contract types provide for responsibilities/risks depending on degree of technical uncertainties. Figure 1 contrasts and illustrates the factors used in selection of the appropriate contract.

This figure contrasts only the major selections of contract arrangements which are commonly used between the government and its aerospace industry contractors, subcontractors, and vendors. The customary contractual use of the profit/fee concept illustrates the strongest distinction between costs-reimbursement contracts (CPFF, CPIF, & CPAF) involve a fee, whereas fixed-price contracts (FPI & FFP) involve a profit. To illustrate the relationship of contract cost outcome and the profit/fee impact of each basic contract, the graphs of Figure 2 are provided.

B. Contractor Motivation to Modernize

Several economic factors are considered by any contractor who is contemplating a productivity improvement in his facility. Under CPFF contracts, the contractor may feel incentivized to underrun cost and affect a higher fee relationship (rate) for his fixed fee. The CPFF arrangement might encourage a contractor to "load up" on non-essential or idle facilities to give stability to his work force. Another problem is the possibility of a contractor overrunning direct cost to absorb fixed charges and overhead.

The CPAF contract provides greater flexibility in deferral of cost of performance objectives specification but is often criticized for the arbitrary subjective evaluation of a contractor's efforts. In designing the award fee evaluation criteria, the distinction between a contractor's inputs (such as personnel attrition, training, neatness, and administrative practices) and delivered outputs (such as test data, facilities constructed, and test completed) is often overlooked. The contractor may be overly motivated to respond to acceptable "inputs" rather than accomplish the contract scope output objectives.

Under CPIF contracts, the risk associated with cost, schedule, and performance objectives are systematically shared between parties of the contract. Multiple incentive arrangements are encompassed in most "sharelines" of fee. These arrangements are so structured to place appropriate emphasis on the penalty-reward considerations for cost, performance, and schedule. Thus, these sharing structures communicate the optimal tradeoffs among these objectives.

In Stimson and Reeve's February 1984 Industrial Engineering article [18] "Industrial Engineering Challenges in the Defense Industries," one of several problems cited in the incentivization for factory modernizations was the inhibiting effect on progress on productivity by the cost-based profit policy of DOD. This policy in certain circumstances penalizes productivity in that when DOD negotiates cost and profits, fee is typically permitted based on a cost relationship. Thus, a contractor may actually see profits reduced as a result of efforts to improve productivity and accordingly reduce cost.

The fixed price contracting environment is for those contracts when there is little or no uncertainties associated with cost, performance, or schedule. The FPI arrangement applies a ceiling price and the range of incentive effectiveness is structured around cost outcomes which will vary little from the negotiated cost estimates. Due to higher risk on the contractor, a higher target profit is provided. Under FFP contract, the contractors reduction of cost reverts to increase in profit while the government does not share in savings.

C. Subcontractors and Vendors

When a prime deals with its subcontractors, these second and third tiers of vendors and suppliers are typically contracted on a firm fixed price basis. These FFP contracts provide the components, assemblies, and parts that the prime aerospace contractor will modify, combine, assemble, and test as an end-product. Often these parts and components will be off-the-shelf hardware or "modified" standard catalog items. In this arena, price may be a market response, a competitive bid, or a standard quote with very little relationship to operations unit cost -- essentially "what the market will bear."

The government relies on competition and an "open" marketplace to assure a favorable and reasonable price. The interrelationship of the subcontractor and the prime contractor under FFP is generally the same circumstances described earlier of the relationship of the prime with the government. The government will usually maintain some degree of control of subcontracting by the approval process under the prime's declared and approved "make or buy" policy. Individual major subcontracts must go through an award approval process between the prime contractor and the government. In the FFP environment, little if any government surveillance or administration is available on operations cost and performance measurement. This factor complicates any assessment of operation for shared shavings in the IMIP program parameters. The General Accounting Office (GAO) has cited this as "needed guidance" to improve DOD efforts to implement IMIP at subcontractors and vendors, stating that mechanisms are needed for analyzing benefits and investments at these contractual levels [19].

III. IMIP PROGRAM HISTORY

A. Background

In an October 1984 IMIP Technical Review, RADM J. S. Sansone, Deputy Chief of Naval Material, presented "The Challenge: Requiring the Industrial Advantage Through Productivity and Technology [16]. "This review gives a broad overview of the issues, concerns, and results of the IMIP Program to date. According to this review, research studies have verified the following disturbing conditions: an eroding defense industrial base, limited surge mobilization capability, capital investment in defense segment low, productivity growth very limited, Defense Acquisition Regulation (76-23)/profit policy not motivating contractors to make substantial capital investments, and general misunderstanding of DOD finance policy and cost principles.

At the same time, industry's concerns have grown in the areas of high overhead costs, excess capacity, low labor productivity, high inventory and material costs, quality assurance, poor sales forecasts, delivering new products on time, and yield problems. If these concerns are not solved a company cannot compete and may choose to abandon the government marketplace. All of these concerns affect a company's productivity. According to [16], influences which act contrary to modernization efforts in the DOD marketplace have been: government provided plant and equipment, much of which is outdated; cyclical nature of defense demand; annual fundings of contracts; short term thinking; and cost based profit policy.

B. IMIP Definition and Procedures

In Figure 3, the IMIP influence and baseline adjustments on a program are charted. The profit strategy of IMIP incorporates good profit margin management with management of asset turnover improvements to facilitate a sound percentage return on assets and investments. The IMIP promises to make quality, reliable hardware systems more affordable, while continually motivating industry through shared savings rewards to be more productive. Admiral Sansone [16] estimates the DOD results to date with projected new contractor productivity enhancing capital investments at $1.3 billion and projected savings to be shared at $4.0 billion.

In the 1984 DOD Guide, "Industrial Modernization Incentives Program (IMIP)" [4], two problems have been cited most frequently as inhibiting productivity modernization progress. First is program uncertainties which hinder investment amortization and inhibit long-term planning. The other is cost-based-profit policy. The low price negotiation concept may have eliminated long-term benefits of investment in modernization. The problem is that profits (cost savings/avoidances) do not increase in the short-run while costs (capital invested) increase significantly because capital must be invested "up-front" of expected benefits. Figure 4 (from [5]) displays the nature of this "up-front" example of cost reduction.

The IMIP is a very targeted and controlled method of encouraging capital investment in productivity. Prior to any business arrangement negotiated under the IMIP, the DOD must be able to recognize the prospect of reduced costs and other benefits which have cost reduction potential. Baseman [1] emphasizes "when more than one DOD Component is doing business with an IMIP contractor, one DOD Component will be assigned the lead and will consolidate the other DOD Component requirements."

C. Strategy and Assessment of Benefit

Other authors [e.g., 17] have recognized that government and industry approach modernization incentives/programs from different perspectives. From the government's perspective, three prerequisites for an effective IMIP application are multi-year procurement, economic production rates, and encouragement of competition. Program stability is vital to program efficiency and productivity improvements. Production rate economies are essential to efficient utilization of facilities. A contractor must not receive an unfair competitive advantage via incentives to modernize and maintain his manufacturing facility.

Other factors relating to the government's comprehensive program acquisition strategy, which should influence the government's decision to begin IMIP project planning, are listed below [from [5]):

1. Realistic budgeting
2. Improved support and readiness
3. Termination protection for purposes other than IMIP
4. Second-sourcing plans
5. Manufacturing and producibility engineering planning
6. Spare parts acquisition
7. Profit policies

8. Interaction with other incentives, such as:
   a. Incentive-type contracts
   b. Value engineering
   c. Design-to-cost
   d. Reliability and maintainability incentives

These considerations must be made to assure plans and techniques are compatible with project strategy and goals and relationships with IMIP incentives are well defined. IMIP should not be confused with efforts to upgrade a manufacturing process in a contractor's facility with direct costing against available government funding. Such efforts have been criticized [17] as promoting "piecemeal, bottoms up" modernization resulting in "islands of technology," with "little consideration for their integration into total or parallel systems." IMIP is usually a plant-wide application with contractor investment.

Companies with aggressive productivity programs will gain the most from IMIP as it overcomes many of DOD's contracting barriers to productivity enhancement. If IMIP is incorporated into a company's internal productivity program, only a minimum additional effort is required to effectively use the IMIP. Furthermore, IMIP methodology [4] forces the industrial engineer assigned to identify productivity improvements to follow a disciplined approach for:

1. Factory analysis - Identifying productivity enhancement opportunities.
2. Benefit prediction - Benefits on opportunities to be exploited.
3. Benefit verification - Verifying actual benefits received versus predictions.

In examining its productivity enhancement activities, a company must look to those activities of the overall business objectives and its current capital investment plans. For IMIP purposes, there are two classifications of capital investment; those made without the influence of IMIP incentives and those with. The first class encompasses investments made to remain currently competitive, to achieve baseline program objectives, to enter new markets and to earn an attractive return on investment (ROI). IMIP is not meant to subsidize, substitute, or replace these outlays.

The second class of investments with IMIP shared savings incentives are for those where an attractive return is not present and where risk due to program uncertainties is at an unacceptable level. According to the DOD

IMIP Guide [4], "The contractor's share of the savings is that share necessary to make the investment an attractive business opportunity and is calculated using the discounted cash flow model . . . for capital investments and a percentage share of savings when the implemented improvements are not capital intensive." The discounted cash flow (DCF) model has been reduced to a computer program which is defined and utilized later in this section.

The level of capital investment with IMIP incentives will be a strategic financial decision for the company. It must decide that IMIP can provide acceptable rate of return and investment recovery and make a commitment of the increased level of capital expenditure. After such a commitment, the company should initiate discussions with the DOD and provide broad plans with simple estimates of cost and benefits. Each cognizant service in DOD, as well as NASA, will probably vary in approach and application. A contractor must recognize these distinctions and differences in policy, resolution, and implementation by these agencies.

For early understandings with the DOD, a memorandum, which satisfies IMIP guidelines but is not a contractual commitment, should provide:

1. The contractor's past, present, and future productivity enhancement program (both content and dollars) without the IMIP incentives.
2. The contractor's increases in productivity enhancement effort if IMIP incentives are provided.
3. The expected benefits of the enhancement effort.
4. The company's projected sales base over the proposed IMIP participation period, including the major DOD programs.

A formal contract arrangement with the company will include approval of productivity projects, contract incentives, IMIP statement of work, and obligation of direct funding, if any, for the government.

D. Prime/Subcontractor Relationships Under IMIP

The subcontractor/vendor base represents a substantial part of most major aerospace program costs, often 50% to 60% of cost. At this tier of subcontractors, the DOD's "multi-services" and NASA are often interlinked. As such, this subtier base offers potential, significant benefits for IMIP initiatives. The subcontractor IMIP involvement may be (1) direct government administered or (2) prime contractor administered under a government contract. The IMIP strategy in this case may be an "industry" approach or "programmatic" approach. The "industry" approach targets a specific sector of the industrial base. The "programmatic" approach attempts to modernize the subtier base of a given major system program.

The prime contractor may administer the subtier program for the government by formal program office management. Its objectives would be to provide management, control, financial incentives, and technology assistance necessary to stimulate vendors implementation of capital equipment investment. Basic management of a subcontract is handled the same way as a direct government program. The prime contractor represents the government and ensures the best interest of the government are being upheld. All actions taken are still subject to the review and final approval of the government.

In the financial investment analysis of the "costs" and "benefits" of an IMIP proposal, several steps are involved:

1. Define the baseline for comparison and expected savings. Analysis requires identification of cost and price if IMIP project was not adopted. There must be agreement on production quantities and schedules.
2. Identify the necessary investment. Specific items, installation, engineering, and time-phased acquisition costs must be developed.
3. Develop a cost and pricing schedule for the proposal. The realistic time-phased expectation of the implementation will influence the depreciation, the imputed cost of capital, and facilities-related profit.
4. Analyze the financial effects -- This step needs a Discounted Cash Flow (DCF) analysis of relevant financial forces.

E. Difficulty in Validating Cost Savings

Cost and benefits of an IMIP application should be reviewed a minimum of three times: economic analysis stage, pre-implementation, and post-implementation. A detailed analysis, usually involving a work breakdown analysis of the process for producing an item, must be performed in order to calculate the cost savings at a level which clearly segregates the effects of the change in the manufacturing environment [5]. The GAO [20] has criticized the DOD and recommended "Better estimates of the savings resulting from IMIP efforts are needed in order to establish program cost-effectiveness." This comment on estimates and on better validation techniques was true for prime contractors as well as administration of subcontractors.

F. F-16 Early Results, Trade, and Projections

On the F-16 program, 60% of the cost represents procurement dollars with subcontractors. In 1984, twenty subcontractors have started modernization programs and have yielded real results -- more than $550 million in DOD savings committed. According to General Dynamics (GD), ninety subcontractors/suppliers are planned for involvement. The subcontractors must use an authorized cost-benefit approach and methodology which assumes a preliminary cost savings analysis in Phase I, a refined analysis in Phase II, and implementation in Phase III. A typical analysis plan and activities in this methodology is displaying in Figure 5 from [9].

The savings on the in-plant GD Tech Mod (IMIP) have been very dramatic. The initial USAF commitment of $25M (contractor research and development at $11M and development effort at $14M) in early 1977 was the forerunner to the Tech Mod program where GD agreed to invest $100M in new facilities to affect 1388 F-16 aircraft. With follow-on contracts, the total F-16 flight units anticipated are 2144 USAF and 75 Peace Marble aircraft. This extremely long production run will have benefited from the thirty-eight in-plant projects and productivity improvements which have been implemented [22].

For a dramatic comparison, the original savings, the validated savings and 1985 savings forecast by GD are shown in Figure 6. It shows saving validated to be 50% greater than estimates in the first seven years.

G. F-16 Goals Attained and New Horizons

The vehicle learning curve experience has been 78% on manufacturing direct labor hours [22]. The USAF considers this a phenomenal rate for aircraft production over this extended period. This fact correlates with a drop in hours per unit from 110,000 in 1977 to 26,000 hours today. These savings relate to lead-time reduction from months to days. Inherent to the basics of IMIP, the ROI at GD is averaging 12-18% [11].

As reported by USAF and GD, the current initiatives include:

1. Program expansion to "non-touch," non-factory labor efficiencies at the GD plant.

2. Increase participants and lower tiers of subcontractors.
3. Additional technical support to assist subcontractors in their initial efforts.
4. Cost management projects at prime and subcontractor to tailor current cost accounting system to meet automation of the manufacturing environment.
5. Creation of computer data bases for enhanced collection, analysis, and dissemination of programmatic, financial, and technical data to government and industry.

In the General Dynamics brochure [23] on the F-16 (1985), the USAF F-16 Industrial Modernization Program Office Manager is quoted, "For every dollar of savings generated, 80 cents flow to other products and programs. For every government dollar of seed funding provided, industry has committed six additional dollars of capital investment and ten dollars of savings to government." He expects to save $1 billion by 1993 in the total production of the F-16 fighter [11]. By any standard of measure, the F-16 IMIP initiative has been highly successful.

IV. EVALUATION OF FEASIBILITY OF NON-DOD IMIP APPLICATIONS

We now describe a methodology [14] that could be utilized by program managers in the Federal government or industrial engineering management at a contractor to evaluate the feasibility of a particular IMIP application, assuming groundrules identical to those used by DOD. The financial attractiveness of a proposal is determined by comparing cost required with the benefit expected. The contractor's net cash flow for an analysis of an investment proposal consists of:

1. Outflows
   a. Contractor facilities investment expenditures.
   b. Contractor income taxes from higher income less investment tax credit per current Internal Revenue Service (IRS) guidelines.

2. Inflows

   a. Imputed cost of money -- based on net book value of incentivized facility investment.

   b. Depreciation on the proposed investment.

   c. Net change in profit (increase or decrease) -- represents the net effect on profit/fee component of price, i.e., profit on depreciation, profit on facilities capital consideration, and any "lost profit" due to reduced contractor effort.

   d. Productivity Saving Reward (PSR) -- formal shared savings which is the incentive of IMIP to produce an adequate contractor IRR on investment.

A. Analytical Model

Analysis of this type is straightforward when a computer program does the computation and keeps track of the agreed-upon items. The cost estimates to be developed are these:

1. The year-by-year investment-related costs (outlays, depreciation accounting practice, relevant profit rates).
2. Other effects of productivity-enhancing investment (lower labor costs, out-of-pocket cost of production).
3. A "business as usual" case with no IMIP-related agreement (initial expected return for contractor and benefit to government without any sharings).
4. Alternative evaluations of "varied" saving shares and shares timing.
5. If disagreements arise, the rate of return may be computed with alternative inputs to highlight the disagreement variances.

The DOD IMIP Steering Group approved [3] the Discounted Cash Flow (DCF) Model, developed and maintained by the Logistics Management Institute, for use as a tool in negotiating IMIP Tech Mod business agreements. Figure 7 is taken from the USAF policy issued pursuant to the DOD IMIP Guide and outlines the steps and items in the computer model. Figure 8 gives a line by line description of each line in the DCF Model [24].

A spread-sheet financial analysis program can handle a return on investment (ROI) model and calculate the internal rates of return (IRR) for a stream of year-by-year net cash flows. In the following sub-section of this paper, a DCF model is developed and employed to evaluate a potential NASA initiative.

An IMIP proposal is based on the expectation of reduced costs and shared savings. The validation of the effects of IMIP effort is important to the assurance and long term credibility of the program application. It is necessary early in the IMIP process to focus on the benefits analysis and verification of the validated process requirements. The system may vary from minimal (evident reduction) to extensive and is dependent on the types of incentives used. The DOD Benefit Analysis is charted on Figure 9 from [24].

B. Example Application

A cash flow computer program, as shown in Figure 10, addresses all the elements of the DOD IMIP program model. In this example, several assumptions are made as follows, reflected in the model input screen (Figure 11). A tooling complex costing $40 million is assumed for capital venture. Cost Accounting Standard (CAS) 409 depreciation is computed on a 5-year sum-of-the-years digits method with an assumption of acquisition by mid-year. Investment tax credit (ITC) and accelerated cost recovery system (ACRS) depreciation assumes the pre-1987 tax regulations. CAS 414 cost of money utilizes the current Treasury Department interest rate on borrowed money. Savings and profit are variable inputs and assumptions based on a forecast of savings inherent in the tooling installation.

With these set of inputs, the DCF model computes a net savings of $48.062M to NASA and $36.938M to the contractor, as shown in Figure 12. This is based on an assumed total savings of $85.0M which is a direct input. Of the $85.0M savings, $10.200M is attributable to profit loss to the contractor due to a lower base. Therefore, the true savings to the contractor is $26.738M ($36.938M - $10.200M). This saving split is based on a 19% return on investment, which is a negotiating criteria. Share line percents would be adjusted as negotiation strategy dictates.

C. NASA IMIP Explorations

Since the early 1960's, the role of NASA's George C. Marshall Space Flight Center (MSFC) has primarily been the design, development, test, and launch of various multi-project, multi-contractor propulsion systems. Most of NASA's aerospace contractors use their own plants with government furnished tooling and have other contracts with one of the DOD tri-services. In some instances, the contractors utilized a government-owned facility and produced a single project item, i.e. NASA's Michoud Assembly Facility in New Orleans where Boeing and Chrysler built the Apollo Program's S-IC and S-IB stages and where Martin-Marietta builds the Space Shuttle's External Tank. In most cases, the government has provided facilities and equipment rent-free.

With the onset (1973) of the Space Shuttle Program, the use of expendable hardware from short production runs (often one-of-a-kind) gave way to the repetitive production required of such items as the External Tank and the Solid Rocket Boosters. This repetitive production opened the possibility for IMIP-like programs at NASA-MSFC. The four major propulsion system contracts that MSFC manages on the Space Shuttle Program are given at the bottom of Figure 13.

These contracts are for ten or more years, valued at $500M to $1500M, and utilize incentives for cost control and improvement. Generally, each of the programs of the Shuttle era have a non-recurring CPAF type of contract environment with the recurring operational costs in a CPIF mode. Prior to the Challenger accident, the trend in contracting for the projects nearing a stable production status was the FPI mode. Due to weaknesses highlighted in the Challenger investigation, the emphasis has reverted to the development mode of CPAF. This mode enables the NASA management a subjective unilateral use of profit measurement and motivation of a contractor. The effect of this return to development mode and CPAF contracting relegates IMIP opportunities to a secondary priority until the Shuttle returns to flight status. Nevertheless, it is likely that with the return to Shuttle launches in mid-1988 and subsequent increases in the launch rate to accommodate defense and Space Station projects, that the opportunity for IMIP applications will once again emerge similar to the explorations reported below.

The Solid Rocket Motor (SRM) prime contractor, Morton-Thiokol, Inc. (MTI), is the only NASA contractor which has explored IMIP opportunities. MTI IMIP efforts are traced back to March 1984 when a new tactical motor plant and equipment were formally brought on-line and installed through IMIP efforts of the U.S. Navy [13]. In November 1984, MTI initiated a complete analysis of all Solid Rocket Motor (SRM) operations at the Wasatch Division. The work breakdown structure was used as the framework for this study. All major cost drivers within the WBS were analyzed, zero-based, and potential improvement were identified.

Over 200 potential projects were identified and evaluated. The study and evaluation technique considered feasibility, potential savings, investment cost, lead time for implementation, verification, or qualification requirements and other factors. From the potential project list, 71 subprojects were selected as suitable for near term implementation and were included in the SRM Buy III Proposal (60 flight sets) which was withdrawn after the Challenger accident.

NASA has encouraged MTI to extend IMIP opportunities to its subcontractors. In March 1985, orientations and presentations were given twenty SRM subcontractors to help them understand the concepts and mechanics of IMIP. Over the next six months, seven possible candidate subcontractors responded with preliminary potential projects or process enhancements. The contractor made site visits and assessed the subcontractor's degree of commitment and scope of projects.

Several issues were raised which fortify the early problems inherent in procurement with government systems contractors. The problems of program instability equate to level of production concerns and commitments. Industry's concern for confidentiality of its cost information bears on the very competitive nature of some market places and suppliers. The danger of favoring one competitive supplier over another risks protests in court. All of these subcontract candidates were in the very early planning stage at the time of the Challenger accident, developing their initial capital investment plans and abilities. Significant interests in IMIP exist when program long range stability and production demand are present. The suppliers' concerns are for production rate, technical acceptability and fair competition. Once these concerns are resolved, the joint NASA-contractor decision to implement IMIP must be based upon cost recovery, rate of return and risk protection.

V. CONCLUSIONS

The DOD has been long concerned that the U.S. aerospace industry was not prepared for either short-term surge conditions nor long-term mobilization. Furthermore, defense contractors (similar to most heavy industry in the U.S.) are using out-moded facilities and tooling and therefore are not as productive as they could be if they modernized. Capital investment planning for long-range operations has been circumvented at these contractor plants by short-term profit strategies and myopic fiscal planning. IMIP was created by DOD to solicit capital investment commitments from progressive firms for the purpose of providing savings to both parties in defense contracts through productivity improvements. These incentivized improvements have proven especially successful for General Dynamics and its subcontractors on the F-16 program.

It has been a government policy not to put one firm in a more competitive posture than another. In fact, competitive forces themselves lead to some modernization efforts. Direct cost funding by agencies such as NASA encourage production readiness improvement. The CPIF mode of contracting has served as the primary motivator for Federal contractors to implement productivity improvements.

Assuming an ideal opportunity is shown to exist at a prime contractor facility or its vendors, IMIP can be readily employed in the first two phases, i.e., analysis and project plan. A performance measurement baseline, purged of others acquisition factors such as quantity changes, engineering changes, and learning curve effects must be developed [7]. The major drawback, which has been recognized by GAO, is the process to validate savings predicted by contrasting a "before-IMIP baseline" with "after IMIP." Most firm's accounting systems are unable to reflect this precise level of detail and distinction between learning, changes, and enhancements. A system of cost accounting and control to afford this level of substantiation could be complex, ponderous, and extremely costly to manage, unless properly designed. To a lesser degree, this problem is inherent in CPIF performance evaluation on an interim (prior to completion) basis. There is a clear opportunity for engineering economy researchers to contribute improved methods to predict and validate cost savings due to modernization, and for contractor industrial engineers to apply these in the IMIP-type arrangements with the Federal government.

Unless a contractor is heavily committed to work under Federal contract to the exclusion of other work, modernization efforts will be more influenced by commercial opportunities. Industry management has been supportive of the IMIP concept, even though they are unanimous in their preference for an improved tax structure and the stability of multi-year procurement as better ways to incentivize modernization. IMIP's role is not to replace these preferred incentives, but rather to provide a justification for long-term investment in facilities and tooling which outweights any consideration of short-term ROI financial criteria. Thus, the government's desire for productive use of its contract dollars can be realized by appealing to the "strategic" or long-term profit desires of the contractors [16].

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FACTOR(S)	FIRM FIXED PRICE (FFP)	FIXED PRICE INCENTIVE (FPI)	COST PLUS INCENTIVE FEE (CPIF)	COST PLUS AWARD FEE (CPAF)	COST PLUS FIXED FEE (CPFF)
RISK - COST	GREATEST ON CONTRACTOR				GREATEST ON GOVERNMENT
ESTIMATES	CERTAINTY OF FAIR AND REASONABLE PRICE	LESS COST CERTAINTY	UNCERTAINTIES IN PERFORMANCE - IMPOSSIBLE TO EST. FIRM COST (CPIF through CPFF)		
APPLICABILITY	●REALISTIC ESTIMATES ●ADEQUATE COMPETITION ●VALID COST DATA ●DEFINITION DESIGN AND SPECS.	●POSSIBILITY OF COST REDUCTION AND PERFORMANCE IMPROVEMENT ●GIVES CONTRACTOR A DEGREE OF COST RESPONSIBILITY AND POSITIVE PROFIT INCENTIVE	●INCENTIVIZE MGMT. ●INCENTIVE PERFORMANCE BY SCH. AS COST INCENTIVES ●RECURRING COSTS AS IN PRODUCTION	●SUBJECTIVE EVALUATION OF PERFORMANCE MEASUREMENT ●OBJECTIVES ESTAB. IN ADVANCE BY MILESTONES OF MEASURABLE PERFORMANCE NON-RECURRING COST	●TERM - RESEARCH LEVELS OF EFFORT REQUIRED IS INITIALLY UNKNOWN ●COMPLETION - R&D EFFORT WHEN DEFINITIVE ●NON-RECURRING COSTS
ESSENTIAL ELEMENTS	●100% RESPONSIBILITY AND RISK ON CONTR. ●GOV'T AND CONTRACTOR AGREE OR PRICE AT INCEPTION	●TARGET COST AND PROFIT ●CEILING PRICE ●PROFIT ADJ. FORMULA ADEQUATE CONTRACTOR ACCOUNTING SYSTEM REQUIRED (FPI through CPFF)	●TARGET COST AND FEE ●MIN. & MAX. FEE ●SHARE-LINES AND FORMULA	●NEG. COST EST. ●BASE FEE ●AWARD FEE WITH EVALUATION CRITERIA	●NEGOTIATED COST EST. ●FEE STATED IN DOLLARS
LIMITATIONS			REGULATORY - FEE @ 15% TARGET COST		STATUTORY - 15% OF ESTIMATED COST
ADVERTISED OR NEGOTIATED	BOTH	NEGOTIATED	NEGOTIATED ONLY - GOVERNMENT AUDITING AND ADM. SURVEILLANCE (CPIF through CPFF)		
MISCELLANEOUS	●MOST PREFERRED BY GOV'T. ●MIN. ADMINISTRATION		●CAN USE COMBINATIONS OF CPIF/CPAF AS APPROPRIATE TO REFLECT DEGREE OF SUBJECTIVITY/OBJECTIVITY OF PERFORMANCE MEASUREMENT METHOD (CPIF and CPAF)		●LEAST PREFERRED BY GOVERNMENT ●LEAST COST RESPONSIBILITY BY CONTRACTOR

Figure 1 Comparison of Five Commonly Used Contract Types

3-1366-7-4w

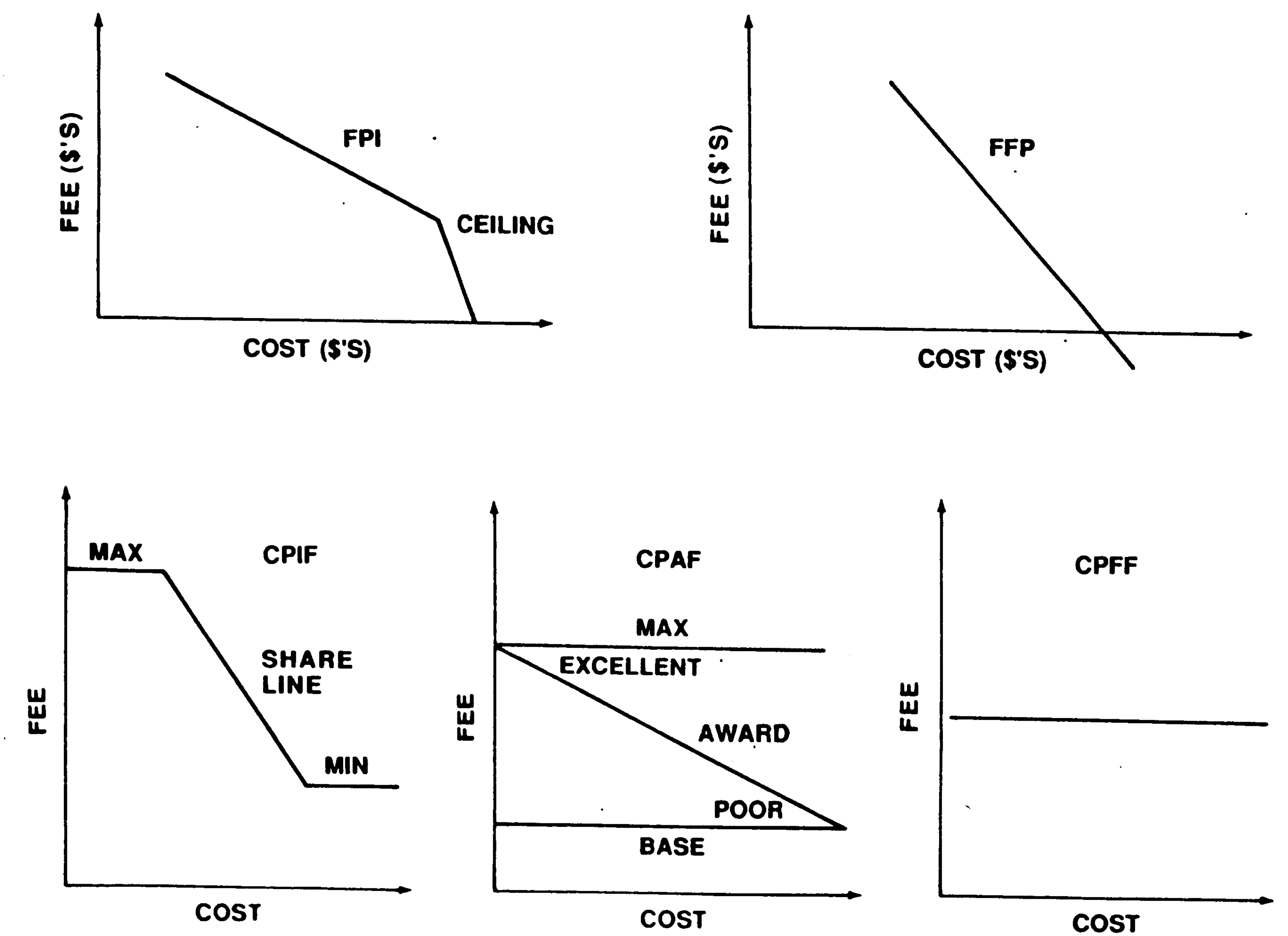

Figure 2 Cost-Fee Relationships for Five Contract Types

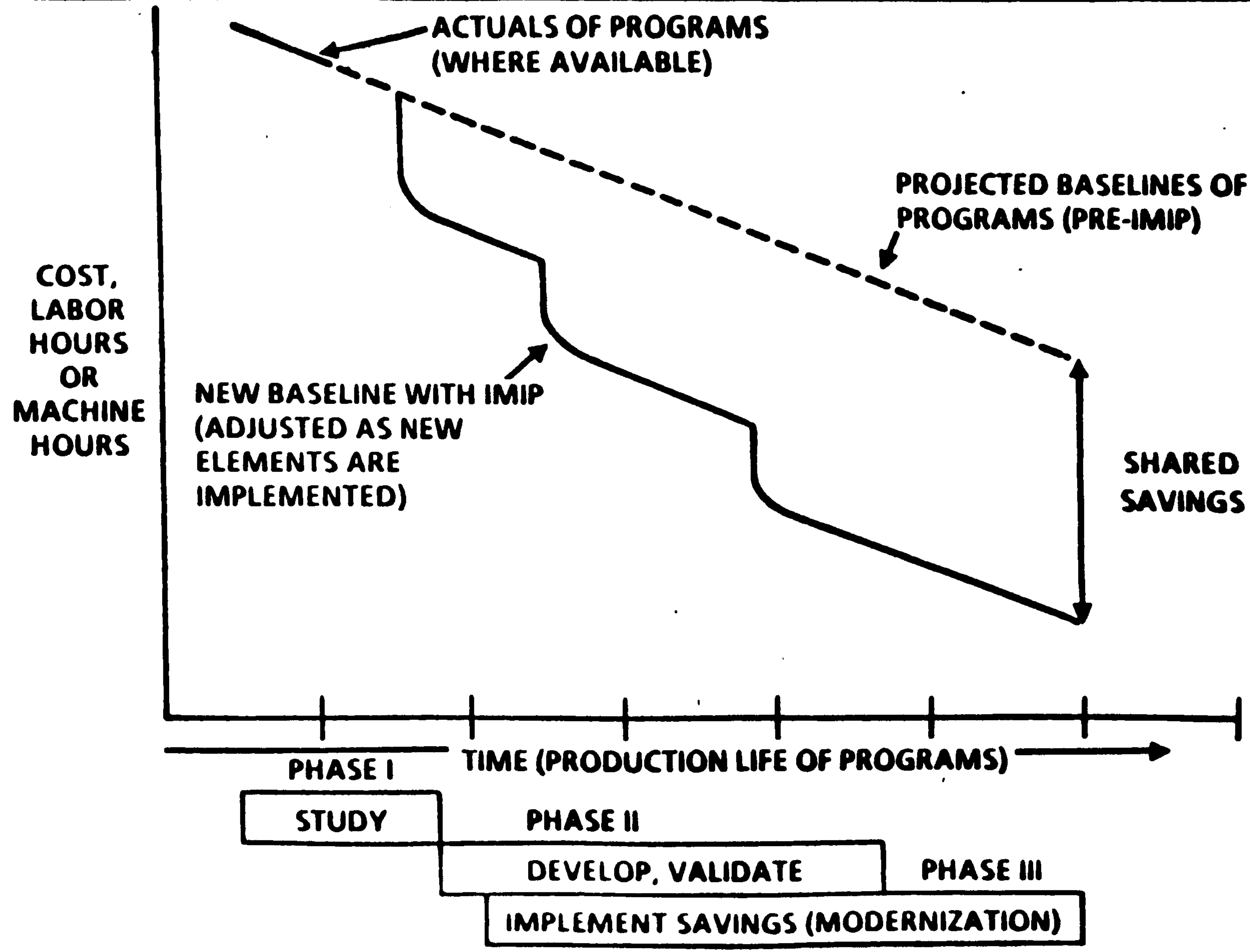

Figure 3 IMIP and Baseline Adjustments to Programs

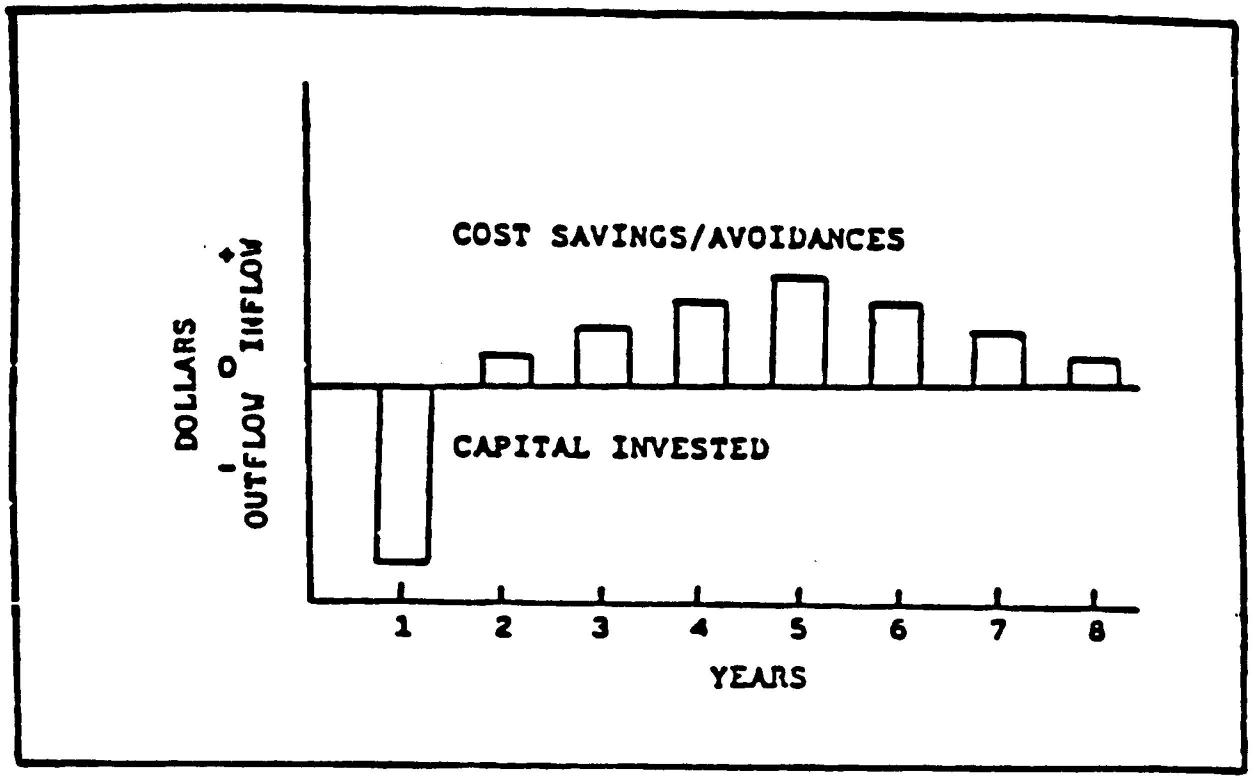

Figure 4 Cost Reduction Example

3-1418-7-4d

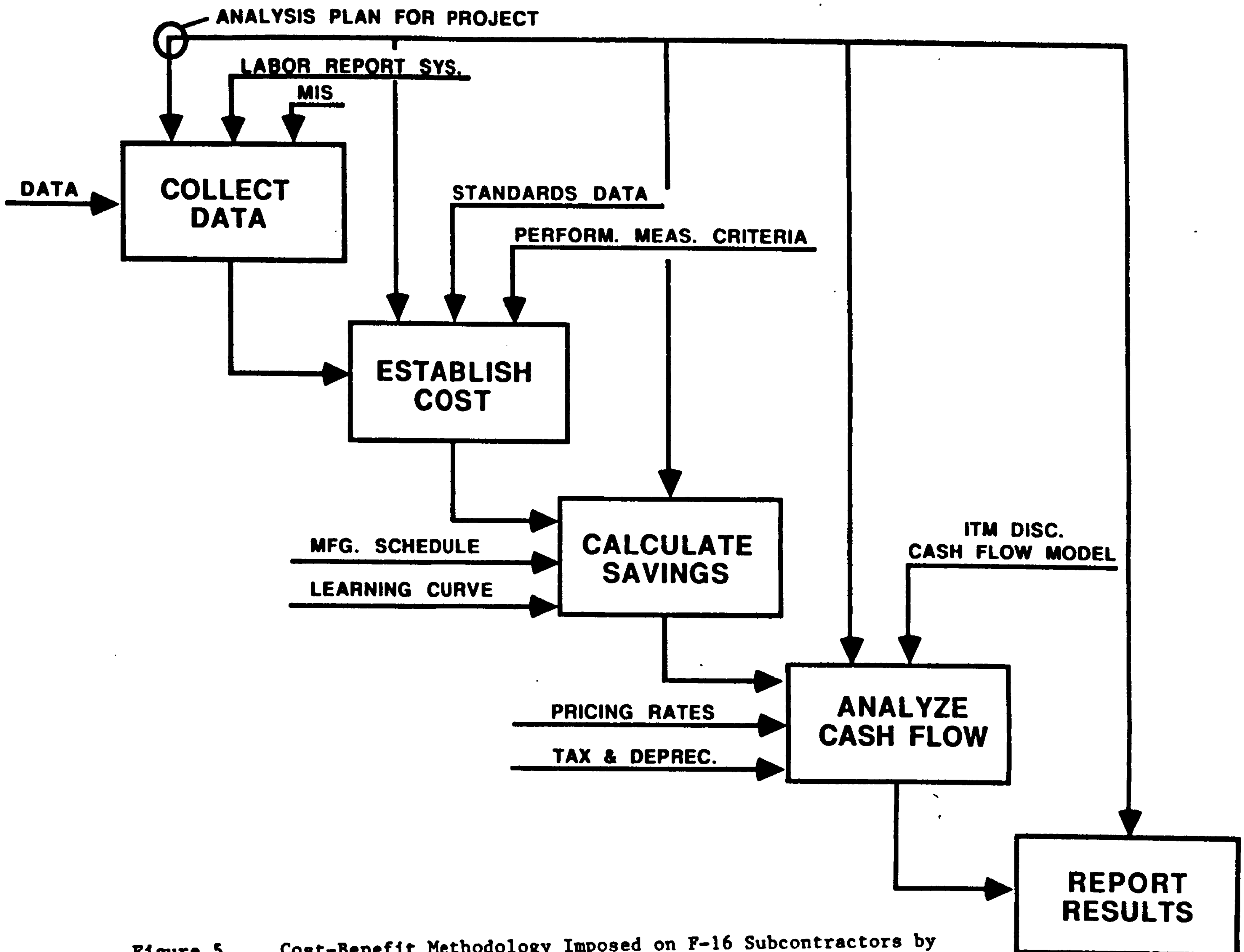

Figure 5 Cost-Benefit Methodology Imposed on F-16 Subcontractors by General Dynamics

3-1419-7-4w

($ IN MILLIONS)	79	80	81	82	83	84	85	86	87	88	89-93
• ORIGINAL SAVINGS	6	18	38	54	77	109	150	197	254	287	-
• VALIDATED SAVINGS	10	33	64	90	122	163	214	-	-	-	-
• '85 FORECAST	-	-	-	-	-	-	-	269	330	396	2594

Figure 6 F-16 IMIP Program Savings Forecast and Validation

Figure 7 Discounted Cash Flow (DCF) Model

Year:		1984 1	1985 2	1986 3	1987 4
SECTION I. CORE DATA					
1 Contractor Investment		0.0	0.0	0.0	0.0
Cumulative Total		0.0	0.0	0.0	0.0
2 Contractor Expenses		0.0	0.0	0.0	0.0
Cumulative Total		0.0	0.0	0.0	0.0
3 DoD/Government Funding		0.0	0.0	0.0	0.0
Cumulative Total		0.0	0.0	0.0	0.0
4 Savings Available to DoD		0.0	0.0	0.0	0.0
Cumulative Total		0.0	0.0	0.0	0.0
SECTION II. INCREMENTAL CASH FLOWS					
5 Retained Savings Incentive		0.0	0.0	0.0	0.0
Cumulative Total		0.0	0.0	0.0	0.0
6 Cost of Money (CAS 414)	xx%	0.0	0.0	0.0	0.0
7 CAS 409 Depreciation		0.0	0.0	0.0	0.0
8 Profit Effect		0.0	0.0	0.0	0.0
9 Subtotal: DoD Cash Flows to Contractor		0.0	0.0	0.0	0.0
10 Salvage Value		0.0	0.0	0.0	0.0
11 Contractor Before-Tax Cash Flow		0.0	0.0	0.0	0.0
SECTION III. TAX CALCULATIONS					
12 ACRS Depreciation		0.0	0.0	0.0	0.0
13 Contractor Taxable Income		0.0	0.0	0.0	0.0
14 Contractor Income Tax	yy%	0.0	0.0	0.0	0.0
15 Investment Tax Credit	zz%	0.0	0.0	0.0	0.0
16 Contractor After-Tax Cash Flow		0.0	0.0	0.0	0.0
Cumulative Total		0.0	0.0	0.0	0.0
SECTION IV. SUMMARY					
17 DoD Program Benefit (Without Incentive)		0.0	0.0	0.0	0.0
Cumulative Total	$0.0	0.0	0.0	0.0	0.0
18 DoD Program Benefit (With Incentive)		0.0	0.0	0.0	0.0
Cumulative Total	$0.0	0.0	0.0	0.0	0.0
19 DoD Payback Period	0.0 years				
20 Government Benefit		0.0	0.0	0.0	0.0
Cumulative Total		0.0	0.0	0.0	0.0
21 Government Payback Period	0.0 years				
22 Contractor Internal Rate of Return					
Without Savings Incentive	0.0%				
With Savings Incentive	0.0%				
23 Contractor Payback Period	0.0 years				

MODEL INPUTS: Year	1984	1985	1986	1987
Contractor Investment	______	______	______	
Contractor Expenses	______	______	______	
DoD/Government Funding	______	______	______	
Savings Available to DoD	______	______	______	
Retained Savings Incentive	______	______	______	
Profit Effect	______	______	______	
Salvage Value	______	______	______	

CAS 414 Rate .... xx% ....
CAS 409 Depreciation: ....
Depreciation Method ......__________.......................................
(1:Straight Line; 2:Sum-of-Years; 3:Sum-of-Years/Half-Year;
4:150% Declining Balance; 5:150% DB, Switch to St Line)
Asset Service Life (years) __________.......................................
Year Placed into Service __________.......................................
ACRS Depreciation: ....
Depreciation Method ......__________.......................................
(1:Standard ACRS Tables; 2:Straight Line) ....
Asset Class (Service Life)__________.......................................
(3: 3-yr; 5: 5-yr; 10: 10-yr) ....
Year Placed into Service __________.......................................
Contractor Tax Rate .... yy% ....
Investment Tax Credit Rate .. zz% ....
Completed Contract - Tax Lag __________ years (0 implies no lag)

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LINE ITEM	EFFECT ON CASH FLOW	DESCRIPTION
I. CORE DATA		
CASH OUTFLOWS: 1. CONTRACTOR INVESTMENT	(-)	● TIME-PHASED FORECAST EXPENDITURES FOR THE CAPITAL EQUIPMENT TO BE ACQUIRED
2. CONTRACTOR EXPENSES	(-)	● EXPENSES THE CONTRACTOR INCURS FOR IMP BUT ARE NOT INCLUDED IN DIRECT OR INDIRECT COSTS
3. DOD/GOVERNMENT FUNDING	(+)	● TOTAL DOD AND OTHER GOV. COST OF IMPLEMENTING THE TECH MOD - FUNDED DIRECTLY
4. SAVINGS AVAILABLE TO CUSTOMER		● TOTAL SAVINGS AVAILABLE TO THE CUSTOMER (BEFORE SHARING) BECAUSE OF IMP. SAVINGS ARE COMUTED YEARLY USING THE DOD BENEFIT ANALYSIS FORM. INCLUDES COST PROFIT TO CONTRACTOR. COST OF MONEY FOR THE IMP FACILITIES IS A REDUCTION TO SAVINGS.
II. INCREMENTAL CASH FLOWS		
CASH INFLOWS: 5. PRODUCTIVITY SAVINGS REWARD (PSR)	(+)	● THIS IS THE CONTRACTORS SHARE OF SAVING FROM SAVING AVAILABLE TO CUSTOMER
6. COST OF MONEY (CAS 414)	(+)	● TREASURY RATE TIMES (X) THE AVERAGE NET BOOK OF THE INVESTMENT YIELDS THE IMPUTED INTEREST NOTE: COST OF MONEY IS NOT INCLUDED IN THE SAVINGS, THEREBY ELIMINATING DOUBLE PAYMENT FOR COST OF MONEY
7. CAS 409 DEPRECIATION	(+)	● IMP INVESTMENT IS RECOVERED THROUGH DEPRECIATION BASED ON USE LIVES NEGOTIATED WITH THE GOVERNMENT
8. PROFIT EFFECT	(-)	● THE CONTRACTOR WILL IN EFFECT LOOSE PROFIT DOLLARS BY VIRTUE OF REDUCING COSTS ON THE CONTRACT ● PROFIT ON THE COST SAVINGS ARE CALCULATED USING WEIGHT GUIDELINES ON THE DIFFERENT COST ELEMENTS OF SAVINGS
9. SUBTOTAL CASH FLOWS TO THE CONTRACTOR		● THE SUM OF CASH FLOWS - LINE ITEMS 4, 5, 6, AND 7
10. SALVAGE VALUE	(+)	● CASH INFLOW FOR RESIDUAL VALUE AT END OF INVESTMENTS ESTIMATED USEFUL LIFE
11. CONTRACTOR BEFORE - TAX CASH FLOW		● THE TOTAL CASH FLOW THE CONTRACTOR HAS ON THE IMP PROJECT BY YEAR, AND BEFORE INCOME TAX CONSIDERATION. IT IS THE SUM OF LINE 1, 2, AND 8.

Figure 8 Description of Discounted Cash Flow (DCF) Model by Line Item

3-1460-7-4d

LINE ITEM	EFFECT ON CASH FLOW	DESCRIPTION
III. TAX CALCULATIONS		
ADJUSTMENT: 12. ACRS DEPRECIATION	(+)	● THE ACCELERATED COST RECOVERY SYSTEM ALLOWS CONTRACTORS TO DEPRECIATE INVESTMENTS MORE RAPIDLY FOR IRS PURPOSES THAN ALLOWED UNDER CAS 409
ADJUSTMENT: 13. CONTRACTOR TAXABLE INCOME		● TAXABLE INCOME CONSIDERING ACRS DEPRECIATION. LINE 8 LESS LINE 2 AND 10
ADJUSTMENT: 14. CONTRACTOR INCOME TAX	(-)	● CONTRACTOR TAX RATE (PERCENT OF LINE 11)
ADJUSTMENT: 15. INVESTMENT TAX CREDIT	(+)	● A TAX CREDIT FOR CERTAIN CAPITAL INVESTMENTS IS ALLOWABLE
NET CASH FLOW: 16. CONTRACTOR AFTER - TAX CASH FLOW		● THIS IS THE CONTRACTOR NET CASH FLOW AS A RESULT OF THE INVESTMENT. IT IS THE SUM OF LINES 8, 12, AND 13
IV. SUMMARY		
17. DOD PROGRAM BENEFIT (WITHOUT INCENTIVE)		● PRODUCTIVITY SAVINGS REWARD AT ZERO - FISCAL VALUE OF BENEFIT IF POSITIVE; OF COST WHEN NEGATIVE
18. DOD PROGRAM BENEFIT (WITH INCENTIVE)		● PROGRAM BENEFIT AFTER DEDUCTION OF PRODUCTIVITY SAVINGS REWARD
19. DOD PAYBACK PERIOD		● PAYBACK PERIOD REPRESENTS TIME REQUIRING TO MATCH DOD - INCURRED COSTS WITH BENEFITS (AMOUNT OF TIME THE CUM VALUE OF 18 IS NEGATIVE)
20. GOVERNMENT BENEFIT		● EQUALS CONTRACTOR INCOME TAX (14) PLUS DOD PROGRAM BENEFIT (18) LESS INVESTMENT TAX CREDIT (15)
21. GOVERNMENT PAYBACK PERIOD		● AMOUNT OF TIME TO RECOUP NEGATIVE CUM VALUES IN LINE 20
22. CONTRACTOR INTERNAL RATE OF RETURN (IRR)		● THE IRR IS THE DISCOUNT RATE THAT WILL MAKE THE PRESENT VALUE OF THE AFTER - TAX CASH FLOW (LINE 16) ZERO
23. CONTRACTOR PAYBACK PERIOD		● THE NUMBER OF YEARS IT TAKES BEFORE THE PROJECT SHOWS A CUMULATIVE POSITIVE CASH FLOW

Fig. 8 (Continued)

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COST AND PROFIT ELEMENTS OF PRICE	1 OLD METHOD ($) COSTS	2 NEW METHOD ($) COSTS	3 INCREMENTAL COST IMPACT (2) - (1)	4 PROFIT %	5 PROFIT CHANGE ($) (3) x (4)	6 ANNUAL PRICE CHANGE($) (3) + (5)
Contractor Effort						
1. Material Acquisition						
2. Engineering Labor						
3. Engineering Overhead						
4. Manufacturing Labor						
5. Manufacturing Overhead						
5.1 CAS 409 Depreciation						
5.2 Property Tax						
5.3 Insurance						
5.4 Maintenance						
5.5 Non-capitalized Investment Costs						
5.6 Other Manufacturing Overhead						
6. Other Costs						
7. G&A						
8. Subtotal: Cost and Profit Changes						
9. Weighted Guidelines Adjustment Factor (-30%)					-30% of Above Subtotal	
10. Weighted Guidelines Profit on Cost Risk			Subtotal Above (Line 8)			
11. Subtotal						
	FACILITIES CAPITAL EMPLOYED (FCE) AND CAS 414 EFFECTS					
	FCE OLD METHOD ($)	FCE NEW METHOD ($)	CHANGE IN FCE (2) - (1)	RATE	PROFIT CHANGE ($) (3) x (4)	PRICE CHANGE($)
12. Weighted Guidelines Profit on FCE						
13. CAS 414 Imputed Cost of Money						
GRAND TOTALS					Profit Effect	Savings Available to DoD

Figure 9 DOD IMIP Benefit Analysis Reporting Format

```
..............IMIPLOG.IL
..............ROWS 2 IS  RESERVED
5 '/SRBIMIPN.IF' READNAMES(2,2,2,5,1.)
100 'EXPENDITURES                 INPUT         '      INPUT
120 'CAPITALIZATION               INPUT         '      INPUT
121 'INVESTMENT TAX CREDIT        INPUT         '      INPUT
122 'NET INVESTMENT               120 - 121     '=120 - 121
123 'CUM CAPITALIZATION           120 CUM       '=120 THRU 10.
140 'DEPRECIATION CAS409          INPUT         '      INPUT
141 'CUM DEPREC                   140 CUM       '=140 THRU 10.
142 'UNDEPR. BAL                  123 -141      '=123 - 141
160 'COST OF MONEY CAS414         INPUT         '      INPUT
220 'CONTRACTOR EXPENSES          INPUT         '       INPUT
300 'CONTR GROSS CASH OUT-FLOW  100-121+220  '=100-121+220
320 'CUMUL CASH OUTLAY            300 CUM       '=300 THRU 10.
360 'SAVINGS AVAILABLE-YR W/PROF INPUT          '       INPUT
370 'PROFIT IN SAVINGS-YR         INPUT         '       INPUT
380 'SAVINGS AVAILABLE-YR         360+370       '=360+370
400 'CUM SAVINGS AVAIL            380 CUM       '=380 THRU 10.
420 'SAVING-CONTR SHARE %(VAR.)    1.000        '=1.000
421 'SAVING- CONTRACTOR $         420*380       '=420*380
440 'SAVING-GOV.SHARE % (VAR.)       0          '=.0
441 'SAVING-GOVT $                440*380       '=440*380
460 'COST OF MONEY-CASH REC        160          '=160
480 'DEPR EXP-CASH REC             140          '=140
500 'SUB-TOTAL CASH TO CONTR.   421+460+480  '=421+460+480
501 'CONTR NET CASH FL BEF TAX     500-300 '=500-300
505 'ACRS DEPRECIATION          INPUT          '      INPUT
510 'CONTRACTOR TAXABLE INCOME  500-505-220  '=500-505-220
515 'CONTRACTOR INCOME TAX         510*.46      '=510*.46
540 'CASH IN FLOW AFTER TAXES   501-515     '=501-515
600 'NET PRESENT VALUE(VAR.)   540@19.0%DISC.'=540 NPVAT 19.
660 'DISCOUNTED C.F. (VAR.)    540@19.0%DISC '=540 DISCOUNT 19.
670 'ANNUAL DIS FACTORS           660/540       '=660/540 FOR 1. TO 10.
680 'CUM CONT DIS CASH FL         660 CUM       '=660 THRU 10.
780 COLUMN 11 = 1 SUM 10
```

Figure 10   DCF Model Logic

```
1 FORMSCREEN(0.) ...............SRBIMIPI.IL    INPUT FOR IMIP FILES
2 FORMSCREEN(23.)
10 '/SRBIMIPN.IF' READNAMES(11,11,1,10,1.)  .......INPUT FILE NAME
......................................
55 READ(88,88,100,11,1.,1.,0.,1.) FOR 1. TO 10.
56 READ(89,89,120,11,1.,1.,0.,1.) FOR 1. TO 10.
57 READ(90,90,121,11,1.,1.,0.,1.) FOR 1. TO 10.
58 READ(91,91,140,11,1.,1.,0.,1.) FOR 1. TO 10.
59 READ(92,92,160,11,1.,1.,0.,1.) FOR 1. TO 10.
60 READ(93,93,220,11,1.,1.,0.,1.) FOR 1. TO 10.
61 READ(94,94,360,11,1.,1.,0.,1.) FOR 1. TO 10.
62 READ(95,95,370,11,1.,1.,0.,1.) FOR 1. TO 10.
63 READ(96,96,505,11,1.,1.,0.,1.) FOR 1. TO 10.
75 = 1.0 .......... 75 76 COLUMN RANGE
76 = 5.0
77 = 45.0 ................THIS IS USED AS A LABEL.
78 = 84.  ............... MESSAGE
80 FORMSCREEN(0.)
81 FORMSCREEN(23.)
83 'F4 = LEFT  F5 = RIGHT  F13 = SAVE DATA  F11 = EXIT'
84 'YEAR 1   YEAR 2   YEAR 3   YEAR 4   YEAR 5'
85 'YEAR 6   YEAR 7   YEAR 8   YEAR 9   YEAR 10'
88 INPUT('EXPENDITURES        ',' ',7.,1.,8.,1.,25.) FOR 75 TO 76
89 INPUT('CAPITALIZATION      ',' ',8.,1.,8.,1.,25.) FOR 75 TO 76
90 INPUT('INVESTMENT TAX CRE ',' ',9.,1.,8.,1.,25.) FOR 75 TO 76
91 INPUT('DEPRECIATION CAS409 ',' ',10.,1.,8.,1.,25.) FOR 75 TO 76
92 INPUT('COST OF MONEY CAS414 ',' ',11.,1.,8.,1.,25.) FOR 75 TO 76
93 INPUT('CONTRACTOR EXPENSES ',' ',12.,1.,8.,1.,25.) FOR 75 TO 76
94 INPUT('SAVINGS AVAIL-YR W/P ',' ',13.,1.,8.,1.,25.) FOR 75 TO 76
95 INPUT('PROFIT IN SAVINGS-YR ',' ',14.,1.,8.,1.,25.) FOR 75 TO 76
96 INPUT('ACRS DEPRICIATION  ',' ',15.,1.,8.,1.,25.) FOR 75 TO 76
110 MESSAGE(83,20.,22.,55.)
111 MESSAGE('78',5.,28.,45.)
113 READSCREEN(1.)
115 IF(113COL1. EQ 11.) GOTO 132
116 IF(113COL1. EQ 4.0)GOTO 75
117 IF(113COL1. EQ 5.)(75=6. FOR 1.;76=10. FOR 1.;78=85.;77=50.; GOTO 80)
118 IF(113COL1. EQ 13.)GOTO 121
119 GOTO '77'
121 FORMSCREEN(0.) ;FORMSCREEN(18.)
122 MESSAGE('SAVING DATA - PLEASE WAIT - ',4.,20.,40.,9.)
.......................................
123 WRITE(88,88,100,11,1.,1.,0.,1.) FOR 1. TO 10.
124 WRITE(89,89,120,11,1.,1.,0.,1.) FOR 1. TO 10.
125 WRITE(90,90,121,11,1.,1.,0.,1.) FOR 1. TO 10.
126 WRITE(91,91,140,11,1.,1.,0.,1.) FOR 1. TO 10.
127 WRITE(92,92,160,11,1.,1.,0.,1.) FOR 1. TO 10.
128 WRITE(93,93,220,11,1.,1.,0.,1.) FOR 1. TO 10.
129 WRITE(94,94,360,11,1.,1.,0.,1.) FOR 1. TO 10.
130 WRITE(95,95,370,11,1.,1.,0.,1.) FOR 1. TO 10.
131 WRITE(96,96,505,11,1.,1.,0.,1.) FOR 1. TO 10.
......................................
132 RETURN('LOGIC USI /SRBIMIPMENU.IL CALC')
133 'END'
```

Figure 11   DCF Input Screen for Example Application

MARSHALL SPACE FLIGHT CENTER
SHUTTLE PROJECTS
IMIP REPORT - TOTAL

			87	88	89	90	91	92	93	94	95	96	TOTAL
100	EXPENDITURES	INPUT	0	12000	28000	0	0	0	0	0	0	0	40000
120	CAPITALIZATION	INPUT	0	12000	28000	0	0	0	0	0	0	0	40000
121	INVESTMENT TAX CREDIT	INPUT	0	1200	2800	0	0	0	0	0	0	0	4000
122	NET INVESTMENT	120 - 121	0	10800	25200	0	0	0	0	0	0	0	36000
123	CUM CAPITALIZATION	120 CUM	0	12000	40000	40000	40000	40000	40000	40000	40000	40000	0
140	DEPRECATION CAS409	INPUT	0	0	6680	12000	9320	6680	4000	1320	0	0	40000
141	CUM DEPREC	140 CUM	0	0	6680	18680	28000	34680	38680	40000	40000	40000	0
142	UNDEPR. BAL	123 -141	0	12000	33320	21320	12000	5320	1320	0	0	0	0
160	COST OF MONEY CAS414	INPUT	0	0	2930	2732	1830	860	330	60	0	0	8742
220	CONTRACTOR EXPENSES	INPUT	0	0	0	0	0	0	0	0	0	0	.0
300	CONTR GROSS CASH OUT-FLOW	100-121+220	0	10800	25200	0	0	0	0	0	0	0	36000
320	CUMUL CASH OUTLAY	300 CUM	0	10800	36000	36000	36000	36000	36000	36000	36000	36000	0
360	SAVINGS AVAILABLE-YR W/PROF	INPUT	0	0	-4500	12300	17900	34100	24600	600	0	0	85000
370	PROFIT IN SAVINGS-YR	INPUT	0	0	80	-1700	-2200	-5000	-1300	-80	0	0	-10200
380	SAVINGS AVAILABLE-YR	360+370	0	0	-4420	10600	15700	29100	23300	520	0	0	74800
400	CUM SAVINGS AVAIL	380 CUM	0	0	-4420	6180	21880	50980	74280	74800	74800	74800	0
420	SAVING-CONTR SHARE %(VAR.)	1.000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.00
421	SAVING- CONTRACTOR $	420*380	0	0	-4420	10600	15700	29100	23300	520	0	0	74800
440	SAVING-GOV.SHARE % (VAR.)	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
441	SAVING-GOVT $	440*380	0	0	0	0	0	0	0	0	0	0	0
460	COST OF MONEY-CASH REC	160	0	0	2930	2732	1830	860	330	60	0	0	8742
480	DEPR EXP-CASH REC	140	0	0	6680	12000	9320	6680	4000	1320	0	0	40000
500	SUB-TOTAL CASH TO CONTR.	421+460+480	0	0	5190	25332	26850	36640	27630	1900	0	0	123542
501	CONTR NET CASH FL BEF TAX	500-300	0	-10800	-20010	25332	26850	36640	27630	1900	0	0	87542
505	ACFS DEPRECIATION	INPUT	0	0	6000	8800	8400	8400	8400	0	0	0	40000
510	CONTRACTOR TAXABLE INCOME	500-505-220	0	0	-810	16532	18450	28240	19230	1900	0	0	83542
515	CONTRACTOR INCOME TAX	510*.46	0	0	-373	7605	8487	12990	8846	874	0	0	38429
540	CASH IN FLOW AFTER TAXES	501-515	0	-10800	-19637	17727	18363	23650	18784	1026	0	0	49113
600	NET PRESENT VALUE(VAR.)	540@19.0%DISC	.3563	0	0	0	0	0	0	0	0	0	13563
660	DISCOUNTED C.F. (VAR.)	540@19.0%DISC	0	-9076	-13867	10520	9157	9910	6615	304	0	0	13563
670	ANNUAL DIS FACTORS	660/540	.000	.840	.706	.593	.499	.419	.352	.296	.000	.000	.000
680	CUM CONT DIS CASH FL	660 CUM	0	-9076	-22943	-12423	-3266	6644	13259	13563	13563	13563	0

Figure 12 DCF Output for Example Application

3-1420-7-4d

TIME	CONTRACTOR	PROJECTS	CONTRACTING MODE
1960-72	APOLLO PROGRAM:		
	CHRYSLER	S-1/S-1B STAGES	CPFF (DEV.)
	BOEING	S-1C STAGE	CPFF (DEV)/CPIF (COST)/CPAF
	NO. AMERICAN (ROCKWELL)	S-11 STAGE	CPFF (DEV)/CPAF
	McDONALD-DOUGLAS	S-1V/IVB STAGES	CPFF (DEV)/CPIF (COST)/CPAF
	ROCKETDYNE	ENGINES H-1, J-2	CPFF (DEV)/CPIF (COST)/CPAF
	PRATT AND WHITNEY	ENGINE RL-10	CPFF (DEV)/CPIF (COST
	IBM	INSTRUMENT UNIT	CPFF (DEV)/CPIF (COST)
1973-ON	SPACE SHUTTLE PROGRAM:		
	THIOKOL	SOLID ROCKET MOTOR	CPAF (DEV)/CPIF (OPNS)
	U.S. BOOSTER, INC.	SOLID ROCKET BOOSTER	CPAF (DEV)/CPIF (OPNS)
	ROCKETDYNE	MAIN ENGINES	CPAF (DEV)/CPIF (OPNS)
	MARTIN-MARIETTA	EXTERNAL TANK	CPAF (DEV)/CPIF (OPNS)

Figure 13 NASA/MSFC Major Program History