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Historically, major Federal programs and projects have experienced substantial cost growth. Overly optimistic estimates, problems encountered during the life of the program, inflation, and uncertainty associated with the estimating process itself contribute to the cost increases.

Findings/Conclusions: Uncertainty is the keynote in decisions involving Federal programs which span many years. Questions such as the following can provide useful and valuable information: What significant uncertainties will drive cost to extremities of a range? What are the chances that an uncertain event will occur? What will minimize the occurrence of an uncertain or risky situation? What is the probability of exceeding the best estimate of cost? of being below the best estimate? At what point in the range will the program cease to be the most cost-effective solution to meet the need? Agencies continue to present early cost projections to the Congress as single-point estimates despite the fact that they are highly misleading. A range of probable cost should be presented in addition to the single, most likely, point estimate which would remain as program and budget cost estimates. Recommendations: Congress should require that each agency submit to the pertinent oversight and appropriation committees an analysis of the uncertainties affecting each program, including: an identification of significant uncertainties that could cause deviations in estimated program cost, a range of potential cost around the point estimate reflecting the potential cost changes, and a statement of the likelihood of the actual cost exceeding certain predetermined levels. (RRS)

5216

REPORT TO THE CONGRESS



BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

A Range Of Cost Measuring Risk And Uncertainty In Major Programs-- An Aid To Decisionmaking

In deciding whether to approve or fund a major program or weapon system, Federal agencies and the Congress must assess (1) need, (2) the most cost beneficial of several alternatives, and (3) what tradeoffs affecting other programs are necessary considering overall national priorities.

Such assessments depend on expected program cost to a far greater extent than in the past. The single-point or specific-dollar estimate now used assumes a certainty as to cost that does not exist.

GAO proposes the use of a range of cost, in addition to the point estimate. Presenting a range of cost should help decisionmakers assess the potential cost impact on the program if these uncertainties occur.



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-163058

To the President of the Senate and the
Speaker of the House of Representatives

Historically cost estimates for major acquisition programs have been presented as a specific dollar estimate. These estimates are more often than not understated due to the uncertainties affecting the major programs. In this report we recommend that cost ranges which measure the potential cost impact of these uncertainties be developed by Federal agencies and presented to the responsible congressional committees for use in their deliberations on major programs.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Acting Director, Office of Management and Budget; Secretaries of Defense and Transportation; Chairmen, House Committees on the Budget, Government Operations, Appropriations, and Armed Forces; Senate Committees on Governmental Affairs, Armed Forces, and the Budget; and Senate Subcommittees on Defense and the Treasury, Postal Service, General Government, Committee on Appropriations

A handwritten signature in black ink, reading "Luther B. Nichols".

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

A RANGE OF COST MEASURING
RISK AND UNCERTAINTY IN
IN MAJOR PROGRAMS--
AN AID TO DECISIONMAKING

D I G E S T

Since the 18th century most Federal agencies have faced the same recurring problem--ultimate costs of programs are often many times the estimated costs on which they were approved. Although Federal agencies make continuous efforts to improve the reasonableness of their estimates, over optimism still exists, inflation continues, and problems of many types plague major programs.

Cost estimating is more art than science. Cost estimates are not statements of fact; rather, they are judgments of the cost to perform work under specified conditions. For programs that span years from the drawing boards to completion, economic uncertainties and technological risks are inherent. The single-point or specific-dollar estimate assumes a certainty as to cost that does not exist.

Substantial deviations between an initial program cost estimate--or point estimate--and actual or ultimate cost are not unreasonable given these inherent uncertainties. One way to assess the problems is determining a range of potential cost by analyzing probable uncertainties and risks that can be reasonably anticipated in a developmental program.

Presenting a cost range should help decisionmakers assess major areas of probable risk and uncertainty and the potential cost of a program if these uncertainties occur. Questions such as the following can provide useful and valuable information:

--What significant uncertainties will drive cost to extremities of a range?

- What are the chances that an uncertain event will occur?
- What will minimize the occurrence of an uncertain or risky situation?
- What is the probability of exceeding the best estimate of cost? of being below the best estimate? of exceeding the upper end of the range?
- At what point in the range will the program cease to be the most cost-effective solution to meet the need?

Agencies continue to present early cost projections to the Congress as single-point estimates despite the fact that they are highly misleading for reasons already stated. As programs proceed and costs vary from point estimates, requirements are not fulfilled, problems exist with what is acquired, future planning becomes unrealistic and unbalanced, program officials are often accused unjustly of mismanagement, and credibility with the Congress and the public is diminished.

The Departments of Defense and Transportation require that uncertainties in major programs be identified for decision reviews but not that a cost range be estimated to quantify the potential cost impact of the uncertainties. The Defense Department, in a January 19, 1977, revised directive on major acquisitions, indicated that ranges may be developed up to full-scale development.

A range estimate will not solve all the problems, and it should not completely replace the point estimate. A range of probable cost should be presented in addition to the single-, most likely, point estimate, which would remain program and budget cost targets. This information can help decision-makers decide whether the program is worth the stated risks; i.e., whether the risks involved are greater than the need or whether to proceed despite the risks. As the program progresses a revised range of probable cost

can be used in deciding whether to continue, revise, or hold the program until critical problems are resolved.

AGENCY COMMENTS

The Defense Department generally agreed with GAO's conclusions and recommendations; the Office of Management and Budget chose not to comment even though action is required by the Office of Federal Procurement Policy; and the Department of Transportation disagreed that a range of potential cost should be presented to the Congress. Transportation believes that:

- Office of Management and Budget Circular A-109 will provide for the identification of risks and increase agency capability to assess cost.
- A cost range will not eliminate any problems and will have the same biases and problems of the single-point estimate.
- The cost range, as well as point estimate, will continue to be questionable unless agencies can afford an estimating capability independent of program pressures.

While adequate implementation of Circular A-109 may improve the identification of risks and uncertainties, GAO believes that a cost range which quantifies the impact of these uncertainties on program cost is essential to effective decisionmaking for major acquisitions. An independent estimating capability is desirable, but the lack thereof does not relieve the agencies of their responsibility of providing reasonable program estimates. (See p. 16.)

RECOMMENDATIONS TO THE CONGRESS

Ranges of potential program cost will provide useful information to the cognizant congressional committees in their deliberations on major Federal programs. Therefore, the Congress should require that each executive agency submit to the pertinent oversight and appropriation committees an analysis of the

uncertainties affecting each major program.
(See p. 16.)

This information could be furnished along with other information currently provided by the agencies. The Congress should require that the Office of Federal Procurement Policy develop guidelines for executive agencies to use in complying with these recommendations.

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ABBREVIATIONS

DOD	Department of Defense
DOT	Department of Transportation
OMB	Office of Management and Budget

GLOSSARY

- Baseline cost estimate** - For most Federal agencies, the initial estimate for congressional approval; for the Department of Defense and National Aeronautics and Space Administration, the estimate made at the time of approval to enter full-scale development.
- Cost range** - The upper and lower dollar limits between which the ultimate program cost will fall.
- Engineering development** - See full-scale development.
- Full-scale development** - That phase of the development cycle in which design and detailed engineering is completed and near-production prototypes are built.
- Major program** - Defined differently by various agencies; generally, a program is considered major if estimated cost exceeds some predetermined amount or is specified, for other reasons, by the head of the agency or department.
- Point estimate** - The estimated cost of a program, stated as a single number.
- Selected Acquisition Report** - A quarterly report on the progress of a major Defense Department acquisition compared with the planned technical, schedule, and cost performance. Initially established in 1968 for use by the Assistant Secretary of Defense (Comptroller), it has evolved into a report that periodically apprises the Secretary of Defense and the Congress on the status of major Defense acquisitions.

CHAPTER 1

INTRODUCTION

On March 27, 1794, the Congress authorized the building of six large frigates which were to form the backbone of the U.S. Navy. The then War Department was assigned the task of acquiring the ships. Nearly 17 months later the six keels were laid. Shortly thereafter, due to delays and cost overruns, the program was cut back to three frigates.

Today, 184 years later, most Federal agencies are faced with the same problem--ultimate costs of major programs are often many times the estimated costs on which they were approved.

Program cost estimates are used for such reasons as evaluating the most cost-effective or cost-beneficial alternatives to meet agency needs, making decisions regarding the initial approval or continuation of programs, and planning for future agency needs. In addition, the Congress must assess national goals and priorities; the costs of major programs can be critical to that process.

Cost estimating is more art than science, and thus, cost estimates are not statements of fact but rather judgments of the cost of work performed under specified conditions. These judgments are made in the face of many uncertainties and risks inherent in programs which span many years, particularly those which embody new technology. The single-point or specific-dollar estimate assumes a certainty that does not exist. Given the inherent uncertainties, substantial deviation between the point estimate and actual program cost is not unreasonable. A cost range based on an analysis of program uncertainties and risks is one way to present to decisionmakers an assessment of the possible deviation.

SCOPE OF REVIEW

We reviewed the extent, cause, and effect of cost overruns in major Federal acquisition programs. We discussed the concept of cost ranges with contractors and military service and other Department of Defense (DOD) personnel and reviewed regulations of DOD and the Department of Transportation (DOT) pertaining to the acquisitions of major programs. We also reviewed literature on the major acquisition process and the costing of major programs, including the development of cost ranges.

CHAPTER 2

POINT ESTIMATES DO NOT REFLECT

ULTIMATE PROGRAM COSTS

In deciding whether to approve major programs, Federal agencies and, in turn, the Congress must not only assess need but total cost and what must be given up or delayed in terms of other programs. In today's economic and political environment, approval for the acquisition of a major program will depend, to a greater extent than in the past, on its expected cost.

A total program cost is presently developed to represent a best estimate of the eventual cost on the basis of information available when the estimate is made. This single-point estimate is made early in the acquisition cycle when little program information is available. These estimates are presented to decisionmakers with an aura of certainty that does not exist. They do not accurately reflect the uncertainties and risks inherent in the acquisition of major programs which span many years and that these uncertainties will have a significant impact on the eventual program cost. Even when provisions for contingencies are included, the point estimate implies a certainty that does not exist.

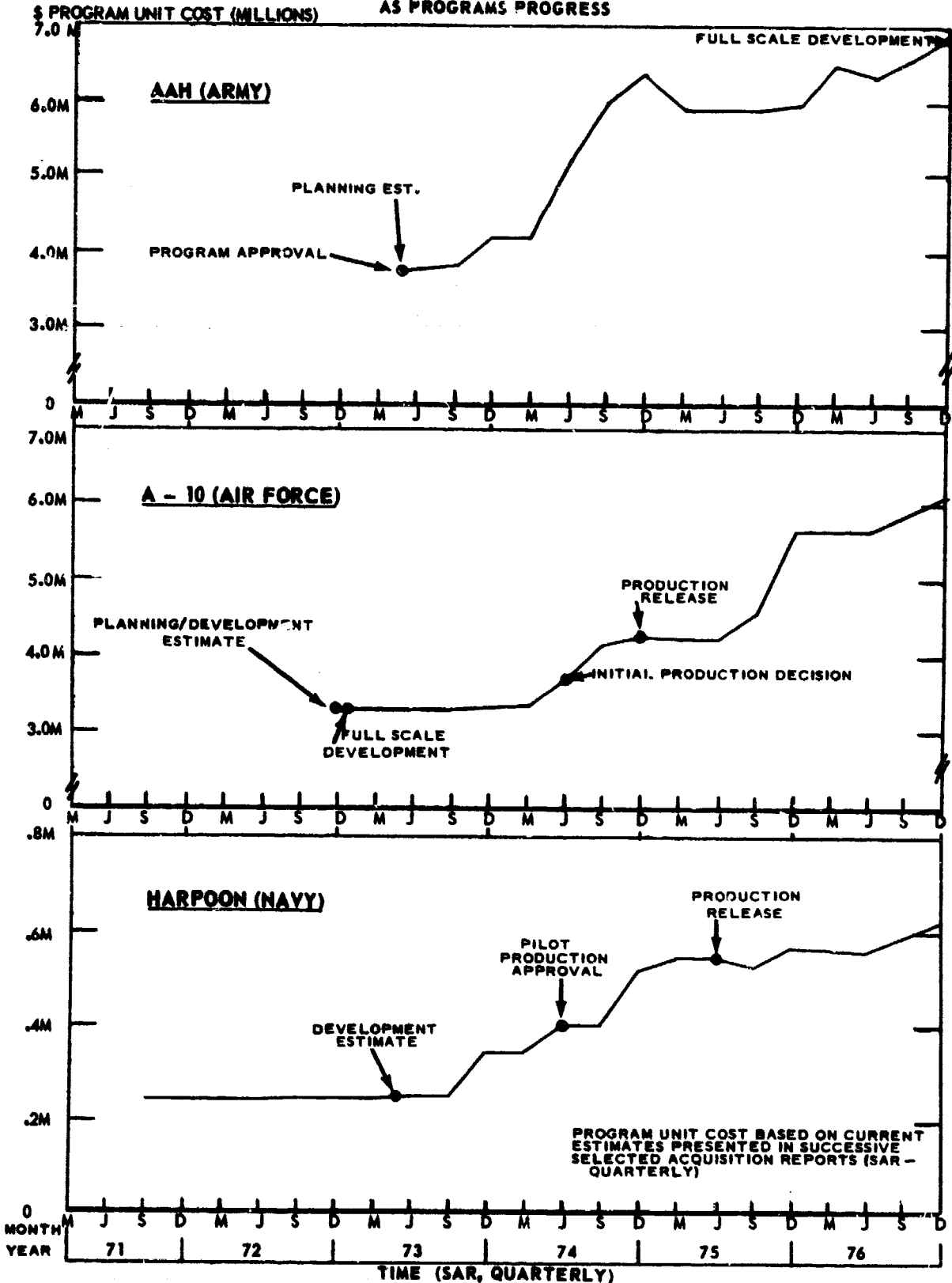
Historically, single-point estimates have been (often significantly) understated. As programs progress updated estimates, more often than not, reflect increases over the previously estimated program costs. For example, in our report "Financial Status of Major Acquisitions, June 30, 1976," 1/ 399 of 547 major civil programs and 86 of 128 major DOD programs 2/ were identified as having increases in estimated cost over the baseline estimate. Of the programs that experienced cost increases, 37 percent of the civil programs and 33 percent of DOD programs had increases exceeding 100 percent.

Chart 1 shows, for three DOD programs, how the unit cost changed as they progressed through the acquisition phases.

1/PSAD-77-62, Jan. 18, 1977.

2/Programs for which baseline estimates were dated before 1976.

CHART 1 -- CHANGES IN PROGRAM UNIT COST ESTIMATES AS PROGRAMS PROGRESS



NOTE: THE SCALE ON THESE GRAPHS ARE NOT THE SAME. NO COMPARISON BETWEEN THE THREE PROGRAMS IS INTENDED.

The effect of underestimating cost simply stated is that the program costs much more than planned, requirements are not fulfilled even at increased costs, problems exist with what is acquired, future planning becomes unrealistic and unbalanced, program officials often are unjustly accused of mismanagement, and credibility with the Congress and the public is diminished.

CAUSES FOR CHANGES IN COST

Many factors contribute to why actual cost is different from the estimated cost on which a program is approved. Cost increases, for example, can result from poor planning and management, political considerations, or the advocacy or optimistic nature of some estimates. However, uncertainty and risk are common traits inherent in all major programs. Uncertainty can be attributed to the cost estimating process itself, inflation, and program uncertainties and risks.

Program uncertainty is associated with the specifications and requirements and how they are affected by future events. This uncertainty includes the availability of funds, scheduling, state-of-the-art of technology, ease of design, and changing needs and requirements.

Agencies have identified inflation as one of the major causes of cost variances, especially in recent years when it has severely affected the total economy. Not only does inflation account for a large portion of the cost variances, but the amount attributed to inflation fluctuates widely. For example, as table 1 on the following page shows, DOD reported economic factors to range from 35 percent of a total net increase for the 6-month period ending December 1974 to 183 percent of a total net decrease for the 6-month period ending June 1975. During this time DOD directed several changes to its method of calculating inflation and/or the rates to be used. We do not know the impact these changes had on this data.

Cost estimating uncertainty is associated with the estimator's ability to provide an accurate estimate of a program on the basis of given assumptions--engineering specifications, degree of difficulty, desired delivery dates, and amounts of material and labor involved. Such uncertainty is attributable to such factors as errors in or inadequacy of data bases, conjecture from extrapolation, variable estimating techniques/methodology, and omission of elements of cost.

Problems caused by inflation, cost estimating, and program uncertainty are further complicated by the advocacy or

Table 1

Variations in Amount of Cost Changes
Attributed to Economic Causes

(in millions)

<u>Time period</u> <u>of change</u>	<u>Type of change</u>				<u>Total</u>
	<u>Economic</u>		<u>All other</u>		
	<u>Amount</u>	<u>Percent</u> <u>of total</u>	<u>Amount</u>	<u>Percent</u> <u>of total</u>	
July 1973 to Dec. 1973	\$ 2,502.9	35.7	\$ 4,513.2	64.3	<u>\$ 7,016.1</u>
Jan. 1973 to June 1974	16,489.7	96.4	618.1	3.6	<u>17,107.8</u>
July 1974 to Dec. 1974	4,659.2	35.2	8,583.3	64.8	<u>13,242.5</u>
Jan. 1975 to June 1975	-3,457.9	182.5	1,563.5	-82.5	<u>-1,894.4</u>
July 1975 to June 1976 (note a)	3,329.7	23.1	11,069.9	76.9	<u>14,399.6</u>

a/This time period is for 1 year rather than for 6 months.

optimistic nature of many estimates. A major program within an agency competes with other agency programs for funds. The agency must then compete with other Federal agencies for a share of the total Federal budget. Since funds are limited program proponents tend to state the most favorable estimate which reflects the assumption that no problems will arise or that problems will have only a minimal impact.

DOD instructions for preparing Selected Acquisition Reports reflect the impact of the above uncertainties in the nine cost-variance categories for reporting cost changes:

1. Quantity change--A change in quantity for the entire system or an integral component to be procured. This does not include changes in support items.
2. Engineering change--An alteration in the physical or functional characteristics of a system or item delivered, to be delivered, or being developed after establishment of such characteristics.

3. Support change--A change in support item requirements (i.e., spare parts, training, ancillary equipment, warranty provisions, Government-furnished property/equipment, testing, etc.).
4. Schedule change--A change in a procurement or delivery schedule, completion date, or intermediate milestone of development or production.
5. Economic change--A change due solely to operation of the economy. This includes changes in the current estimate resulting from actual escalation different from that previously assumed and revision of the assumption regarding future escalation.
6. Estimating change--A change in program cost due to a correction of error in preparing the planning estimate or development estimate or the refinement of a prior current estimate for reasons not provided for in other cost-variance categories; i.e., engineering schedule, economic, etc.
7. Unpredictable change--A change caused by acts of God, work stoppage, Federal or State law changes or other similar unforeseeable events. Unforeseeable events include extraordinary contractual actions under the authority of Public Law 85-804, except that formalization of informal commitments should be reflected under the other categories, as appropriate, and not included under this category.
8. Contract performance incentives--A net change in contractual amount due to the contractor's actual performance being different than was predicted by performance-(including delivery) incentive targets; as differentiated from cost-incentive targets; established in a fixed-price incentive or cost-plus-incentive-fee contract. This category also includes any changes in amounts paid or to be paid a contractor due to (1) award-fee contract or (2) the sharing provisions of a value-engineering-incentive clause included in any type of contract.
9. Contract cost overrun (underrun)--A net change in contractual amount over (under) that contemplated by a contract target price, estimated cost plus fee, or redeterminable price due to the contractor's actual contract costs being over (under) target or anticipated contract costs but not attributable to any other cause of cost growth previously defined. Offsetting profit or fee adjustments attributable

to cost-incentive provisions, if any, shall be considered in determining the net contract cost overrun (underrun).

Total changes between the DOD and civil agencies programs are summarized in table 2. The summary of changes attributed to each variance category and the total change by individual program varies significantly among the different programs which make up the grand total. The cumulative effect of these periodic cost adjustments could eventually result in a program costing many times its original estimate-- often the primary basis on which it was approved.

Table 2

Summary Of Defense And Civil Program Cost Changes

(in millions)

Variance category	FY 74		DOD programs FY 75		FY 76		Civil Programs (For programs having cost growth exceeding 100 percent) From baseline estimate to June 1975				From baseline estimate to June 1976	
	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent
Quantity	\$ -146.2	-1	\$3,299.9	29	\$3,345.9	23	\$ 7,672.4	17	\$13,288.8	17	\$12,900	14
Engineering	1,943.6	8	732.2	6	233.6	2	19,118.8	41	22,690.2	29	24,900	28
Support	-57.9	1	802.2	7	387.9	3	39.5	0.1	48.4	0.1	300	-
Schedule	1,722.8	7	3,618.1	32	2,856.2	20	405.8	0.9	172.6	0.2	1,100	1
Economic	18,992.6	79	1,201.3	11	3,329.7	23	2,024.1	4	36,632.5	46	42,700	47
Estimating	351.5	1	1,244.5	11	4,256.0	30	10,487.0	23	1,185.8	1	3,700	4
Sundry (note a)	1,317.5	5	449.9	4	-9.7	-	6,714.3	14	5,373.9	7	4,700	5
Total change	\$24,123.9		\$11,349.1		\$14,399.6		\$46,461.9		\$79,372.9		\$90,300	
Total programs	b/55 c/49		d/50 e/47		53		59		120		148	

a/Sundry includes items 7, 8, and 9 on page 6 and other changes not accountable for in other categories.

b/6/73 to 12/73

c/12/73 to 6/74

d/6/74 to 12/74

e/12/74 to 6/75

CHAPTER 3

RANGES OF POTENTIAL COST--A MEASURE OF THE IMPACT OF PROGRAM UNCERTAINTY

Cost ranges have been proposed for many years within and outside DOD. The Commission on Government Procurement recommended in 1972 an estimate of program cost within a probable range until the system reaches the final development stage. Our report entitled "Cost Growth in Major Weapon Systems," ^{1/} stated that "Ranges of cost may be meaningful and more useful to both DOD and the Congress in choosing weapon systems to acquire." Most recently the DOD Acquisition Advisory Group, in reviewing the acquisition of major weapon systems for the Deputy Secretary of Defense, stated that the single-cost number implies a certainty that does not exist and that a range which reflects the uncertainty inherent in most acquisition programs would be more realistic. Even though ranges have been advocated for many years and most people agree that they would be more reasonable than the point estimate, they are not required and have not been used except in limited cases. A discussion of cited objections is given on page 11.

HOW DECISIONMAKERS WOULD USE A RANGE OF POTENTIAL COST

The range of potential cost is a means of providing agency decisionmakers and the Congress with an assessment of the cost impact of the risk and uncertainty in the program. With this information decisionmakers can decide whether the program is worth the stated risks; i.e., whether the risks involved are greater than the need or whether to proceed despite the risks.

As the program progresses and additional information becomes available, new cost estimates and a revised range of potential cost can be used in deciding whether to continue, revise, or hold the program in abeyance while additional work in a particular area is performed.

To assist in making a decision about a program and in assessing the risk in the program, questions such as the following concerning program uncertainties and the range of probable cost will provide valuable information:

--What are the significant uncertainties that will drive the cost to the extremities of the range?

^{1/}B-163058, Mar. 26, 1973.

- What are the chances that the uncertain event will occur?
- What is being done or can be done to minimize the occurrence of the uncertain or risky situation?
- What is the probability of exceeding the best estimate of cost? Conversely, what are the chances of being below the best estimate? What are the chances of exceeding the upper end of the range?
- At what point in the range will the program cease to be cost-effective in relation to alternatives; i.e., as cost increases, will the program continue to be the most cost-effective solution to meet the need?

RANGES USED IN SELECTING ALTERNATIVES

One factor considered in selecting a particular program to meet a given requirement is how cost-effective or cost-beneficial the program is in relation to alternative programs.

A cost-effectiveness (benefit) analysis gives a relative measure of program effectiveness versus the anticipated program cost. A cost-effectiveness analysis based on a single-point estimate could be biased by a low estimate. Hypothetically, consider two configurations, system A and system B. The decision is to choose between the two configurations. Assume that the only difference between them is the cost--system B is estimated to cost less than A. They each equally meet the need. Looking at the point estimate only, the decisionmaker would choose the least costly system--everything else being equal.

However, assume that there is much uncertainty associated with system B and that a range of cost reflecting this uncertainty shows a potential for an increase in the cost of system B which would significantly exceed the high estimate of system A. The decisionmaker now has information to use in deciding whether to avoid the possible extreme cost by choosing A or to gamble on overcoming the uncertainty and achieving the expected low cost of B.

RANGE AS AN AID TO PROGRAM MANAGEMENT

Although a range of cost is primarily envisioned as a tool to be used by major decisionmakers, it can also provide valuable information for day-to-day program management.

Program managers and engineers usually recognize the risks in their programs. However, they often do not consider the full impact of these problems on cost, schedules, and performance.

Uncertainties arising in one aspect of the program, may cause problems in another part. For example, the occurrence and subsequent solution to a technical problem in one area of the program may require extensive changes be made in other areas which can lead to schedule slippages and cost overruns. Identifying such interdependencies highlights those problem areas which tend to permeate the whole program.

The data gathered to develop a potential cost range can be used as management checklists. Many risky areas, through early identification, analysis, and corrective action, cease to be so before they would seriously affect program progress.

IMPORTANT ELEMENTS OF RANGES

Although ranges of cost have been advocated before, and most people agree that they are more reasonable than single point estimates for developmental systems, many reasons have been given for not implementing their use. These include:

- Cannot budget for a range of cost.
- Self-fulfilling prophecy--the cost will automatically go to the high estimate.
- Already have threshold values.
- Problems will not be solved.

We believe, however, that having the range and the best single-point estimate dispels these "objections."

Devising cost ranges in no way alleviates agency responsibility of providing the best and most reasonable estimate of the expected program cost. A range of probable cost should be presented in addition to--not in lieu of--the single-, most likely, point estimate, which would remain program and budget cost targets. The single-point estimate would be the cost from which program progress is measured and that program managers should strive to meet. The range would highlight program uncertainties for use by decision-makers.

The upper end of the range would not be a threshold value or a not-to-exceed cost but a statement of the potential program cost if the identified areas of risk occur.

The decision to approve the program could be reversed before the upper range is reached; the program could continue even though the estimated cost has exceeded the upper end of the probable range. All decisions are based on the facts available at the time--the range of cost is just a part of that information.

Cost ranges will not provide the decisionmaker with yes or no answers. Judgments will have to be made considering the range, program uncertainties which drive the range, and other available information. Some programs will be worth a greater risk (wider range) than others.

Generally, there will be a larger range interval between the point estimate and the high cost than between the point estimate and the low cost because the advocacy nature or optimism of the estimates will tend to push the point estimate toward the low end. Another reason is that problems are contagious. A problem in one area often creates problems in other areas. Unfortunately events which cause cost underruns are seldom catching.

CHAPTER 4

DEVELOPING RANGES OF POTENTIAL COST

Current DOD and DOT policies require that risks and major issue areas be identified as part of the formal acquisition review process. In January 1977 DOD revised its directives concerning major system acquisitions (Directives 5000.1 and 5000.2 dated Jan. 18, 1977). Although not specifically stated, the new directives indicate that cost ranges and other program elements may be established up to the full-scale development phase. However, ranges of potential cost are not required to quantify uncertainties. Ranges were developed for some DOD systems along with the independent cost estimates prepared for the Defense System Acquisition Review Council. We reviewed three of these estimates of ranges, held discussions with various DOD and contractor personnel, and researched the development and use of ranges. In this process we identified the following three basic components or steps in developing and presenting ranges of probable costs.

IDENTIFYING PROGRAM UNCERTAINTIES AND RISKS

Every program has some degree of risk and uncertainty--factors or events which can and will affect the program and its ultimate cost. A list of everything that could affect the program would be impossible. The same uncertainties and risks will not affect every program to the same degree and different programs will have different uncertainties. The estimated cost of a program entering development may be influenced more by uncertainties of a technical nature, whereas, a program in production may be influenced more by uncertainties concerning the production base or quantities procured. A program that is advancing the state-of-the-art may be more susceptible to design problems than a program which is utilizing existing, well-proven technology.

Each program should identify those uncertainties which may have the most significant effects. Properly identified and documented, this should avoid giving a distorted picture of the risks involved and eliminate bias when making comparisons between programs. Although DOD and DOT require that major risks be identified, we could not find any guidance or criteria for doing so.

Inflation is a great uncertainty, but the range should be developed in constant dollars. The effects of inflation can then be computed using, for example, varying rate assumptions.

QUANTIFYING UNCERTAINTY INTO A COST RANGE

Many methods can be used to quantify program uncertainties into a cost range. Various organizations within DOD and such corporations as Rand, General Research, and Hughes have researched the identification and quantification of program uncertainties.

We reviewed range estimates made for three DOD programs and techniques for quantifying uncertainty proposed by other DOD units and civilian organizations. All the methods for generating ranges were different but were based on the application of standard cost estimating, statistical or system analysis techniques. There does not appear to be any single, preferable, or universal approach. The approach taken would depend on the nature and complexity of the problem, the time allowed to perform the analysis and the analyst's preferences.

LIKELIHOOD OF A COST OVERRUN

A cost range quantifying program uncertainty is, of course, better than the single-point estimate, but it provides no information about the nature of the uncertainty. Are all the values in the range equally likely to occur? Do those values closer to the point estimate have a greater chance of occurring than those near the extremities? This type of information would be extremely valuable to the decisionmaker in assessing program risks and should be communicated in the form of a statement assessing the likelihood of uncertainties and/or cost occurring.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Historically, major Federal programs and projects have experienced substantial cost growth. Overly optimistic estimates, problems encountered during the life of the program, inflation, and uncertainty associated with the estimating process itself contribute to the cost increases.

Uncertainty is the keynote in decisions involving Federal programs which span many years. To make informed judgments decisionmakers need all the pertinent information that can be provided.

Although efforts can and should be made to continuously improve the reasonableness of program estimates, over optimism still exists, inflation still abounds, and problems of all sorts continue to plague many major programs. A range of probable cost, in addition to the single-point estimate, while not solving all problems that can affect the cost estimate, will bring before management and other decisionmakers information on major areas of probable risk and uncertainty and their potential impact on total program cost if these events should occur.

The range of cost, like the point estimate, will not be a panacea. It will not provide an answer for decisionmakers. However, it will provide decisionmakers with additional information necessary to make informed judgments.

AGENCY COMMENTS

DOD generally agreed with our report and its conclusions and recommendations (see app. I). The Office of Management and Budget (OMB) chose not to comment even though our recommendations would require some action by the Office of Federal Procurement Policy. DOT disagreed with the recommendation that a cost range should be developed and presented to the Congress (see app. II).

DOT believes that:

- OMB Circular A-109, when implemented by agencies, will go far in assuring the identification of risks and increasing their capability to assess cost.
- The range of cost will not eliminate the optimism and advocacy nature of estimates.

--Estimating cost range will have the same biases as the point estimate, and the upper end of the range will become the "desired" single-point estimate.

---The range of cost, as well as the program cost estimate, will continue to be questionable unless an estimating capability independent of program pressures is available.

Although we recognize the potential improvements arising from implementation of Circular A-109 and the limitations of a cost range, we believe that the information it would provide is essential to effective decisionmaking in major program acquisitions. Circular A-109, issued on April 5, 1976, is a new policy for the acquisition of major systems which requires agencies to identify early, for the Congress, the systems' mission need. However, it does not require that a cost range which quantifies program uncertainty be developed. Although adequate implementation of Circular A-109 may indeed increase the emphasis on identification of risks and uncertainties, we believe that a range of cost which quantifies the impact of these uncertainties on program cost is necessary information for the decisionmakers in all phases of program acquisition. Our report states that the range of cost is not a panacea. The range highlights the uncertainties inherent in major acquisition programs and provides the decisionmakers with an assessment of their potential impact on program cost.

Although an independent estimating capability is desirable, the lack thereof does not relieve agencies of the responsibility to provide reasonable program cost estimates.

RECOMMENDATIONS

A range of potential program cost will provide the cognizant congressional committees useful information for their deliberations on major Federal programs. Therefore, the Congress should require that each executive agency submit to the pertinent oversight and appropriation committees an analysis of the uncertainties affecting each program, to include:

--An identification of significant uncertainties that could cause deviations in estimated program cost.

--A range of potential cost around the point estimate reflecting the potential cost changes.

--A statement of the likelihood of the actual cost exceeding certain predetermined levels.

This information can be provided along with other information currently provided by the agencies. The Congress should require that the Office of Federal Procurement Policy develop guidelines for the executive agencies to use in complying with these recommendations.



DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

19 JUL 1977

Mr. R. W. Gutmann
Director, Procurement and
Systems Acquisition Division
U.S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Gutmann:

This is in reply to your letter to the Secretary of Defense dated 14 April 1977 which forwarded copies of your draft report entitled "A Range of Potential Cost as a Measure of Uncertainty in Major Programs" for DoD review (OSD Case Number 4600).

The DoD agrees, in general, with the report and its conclusions and recommendations. The DoD routinely uses multiple cost estimates developed by independent sources which include ranges of estimates for its major programs as part of the Defense Systems Acquisition Review Council (DSARC) process. We intend to continue this type of analysis for major programs, with emphasis on the early phase of acquisition, as an aid in the decision-making process.

A major concern is that assigning probabilities of occurrence to various events which could impact program costs would be highly subjective in nature. Since these cost impacts are not statistically independent, even more subjectivity is required to determine the probabilities of exceeding predetermined cost levels. To emphasize the subjectiveness of these assessments, the term "probability" as used in the recommendations should be dropped in favor of a word such as "likelihood" which has a more subjective connotation.

[See GAO note, p. 19.]

[See GAO note.]

We appreciate the opportunity to comment on your draft report.

Sincerely,


William J. Perry

Attachment

GAO note: Deleted paragraph on specific comments on the wording of this report were incorporated and are no longer pertinent.



ASSISTANT SECRETARY
FOR ADMINISTRATION

OFFICE OF THE SECRETARY OF TRANSPORTATION

WASHINGTON, D.C. 20590

June 22, 1977

Mr. Henry Eschwege
Director
Community and Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Eschwege:

We have enclosed two copies of our reply to the GAO draft report on the range of potential cost in major programs. Please let us know if we can assist you further.

Sincerely,

A handwritten signature in cursive script that reads "Edward W. Scott, Jr." followed by a period.

Edward W. Scott, Jr.

Enclosures

DEPARTMENT OF TRANSPORTATION-REPLY
TO
GAO DRAFT REPORT OF APRIL 1977

A RANGE OF POTENTIAL COST AS A MEASURE OF UNCERTAINTY IN
MAJOR PROGRAMS

SUMMARY OF GAO FINDINGS AND RECOMMENDATIONS

GAO -- through a review of cost overruns in Federal acquisition programs, discussions with contractors and Department of Defense (DOD) personnel, and a review of literature on the subject of the major acquisition process and costing of major programs -- concluded that the development of a range of cost estimates on major programs, in addition to the point estimate now developed, would provide the Congress with additional information on which to make informed judgments on major programs.

GAO recommends that Congress should require the executive agencies to submit an analysis of the uncertainties affecting each major program. Such analysis would include:

- o An identification of significant uncertainties which could cause deviations in estimated program cost;
- o A range of probable costs with respect to the estimated program cost; and
- o A statement of the probability of the actual cost exceeding certain predetermined levels.

GAO feels that this information can be provided to Congress in conjunction with other information currently submitted by an agency, and advocates that Congress should require the Office of Management and Budget and the Office of Federal Procurement Policy to develop guidelines for executive agency compliance with these recommendations.

DOT POSITION STATEMENT

In general, the Department concurs with the concept that program risk should be identified on major programs and that an appropriate analysis of that risk be provided to the decision maker. As GAO correctly points out in the report, the Transportation Systems Acquisition Review Council includes risk assessment in its evaluation of the desirability of proceeding with selected DOT programs at key decision points in the acquisition process.

The draft report, however, does not provide any new insight into ways to eliminate two of the major biases cited for contributing to the unreliability of existing point estimates, namely optimism and advocacy. These biases would most likely be transmitted to the calculation of a range of costs as well, resulting in an upper estimate achieving a value consistent with a "desired" single point estimate. It appears that the ability to predict the range of costs on each side of the point estimate would be about as sound as the ability to predict the original point estimate. In our opinion there would be a serious problem in estimating the risk or the probability that some part of the risk will occur and communicating that probability in a meaningful form with any credibility to Congress.


GAO does not mention in its draft report that the Office of Management and Budget, through the Office of Federal Procurement Policy, has issued a new policy for the acquisition of major systems. The new policy, OMB Circular Number A-109, "Major Systems Acquisitions," dated April 5, 1976, is intended to reform the major systems acquisition process by reducing cost overruns and eliminating the controversy as to whether new systems are needed. The Circular allows each agency to prescribe dollar thresholds or other criteria for determining which agency programs are designated major programs, and the guidance in the Circular is consistent with the recommendations of the Commission on Government Procurement. The Circular requires:

- o Top level management attention to the determination of agency mission needs and goals;
- o An integrated systematic approach to establishing mission needs, budgeting, contracting and managing programs;
- o Early direction of research and development efforts to satisfy mission needs and goals;
- o Improved opportunities for innovative private sector contributions to national needs;
- o Avoidance of premature commitments to full-scale development and production;
- o Early communication with Congress in the acquisition process by relating major system acquisitions to agency mission needs and goals; and
- o Development of an agency capability to estimate and project life cycle costs, and analyze and evaluate contractor and Government risks.

-3-

It appears that agency implementation of OMB Circular A-109 would go far to accomplish the essential recommendations of the GAO report--identification of risk and an increased agency capability to assess cost. It seems desirable to allow Congress access to internal agency risk analysis and cost assessment studies when requested, rather than require agencies to generate additional detailed cost information on all major programs.

Specific program cost estimates as well as probability ranges which may be associated with them will continue to be of questionable value unless an agency can afford in-house estimating capability which would be independent of program pressures. Consequently, we do not see the viability of developing a separate range of cost data to submit to Congress on each major program.


William P. Davis
Deputy Assistant Secretary
for Administration

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