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Evaluating Technical Work in Cost-Plus Contracts

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Inability to predict advanced technology costs forces use of cost-plus-fixed-fee contracts. Yet milestone costs for work already accomplished in such projects are difficult to determine, too. Here's a NASA-based plan that solves some of these problems—

EVALUATING TECHNICAL WORK IN COST-PLUS CONTRACTS

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PERT (Program Evaluation and Review Technique) was designed to be used as a total management system. It was intended to be a practical system, utilizing various administrative and management tools for total program management. Volumes have been written on PERT and the benefits received from its use, but the system is still a long way from being a panacea for Government-industry problems.

The leading proponents of the use of PERT with costs have been the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA). The PERT and Companion Cost System is described as a common framework for integrating costs, schedules, and control in scientific and technical defense and aerospace projects, under Government procurement contracts.[1]

However, the companion cost portion of the PERT system has not functioned satisfactorily on certain types of contracts, particularly those involving research and development projects. PERT has not been able to give management enough accurate information because of the difficulty of forecasting costs in advanced technology.

Contractors' inability to predict advanced technology costs forces Government and industry to use cost-plus-fixed-fee contracts. Although the Department of Defense has oriented its operations toward incentive and fixed-cost contracts, most research and development work procured by the Government must be accomplished under cost-plus-fixed-fee contracts because of of the cost uncertainty.[2] The "risk" element in developing new technology and science is so high that no contractor will undertake Gov-

[1] *NASA, PERT and Companion Cost System Handbook,* National Aeronautics and Space Administration, October, 1962.

[2] Frederic Scherer, *The Weapons Acquisition Process: Economic Incentives,* The Graduate School of Business Administration, Harvard University Press, Boston, Massachusetts, 1964, pp. 2 and 191.

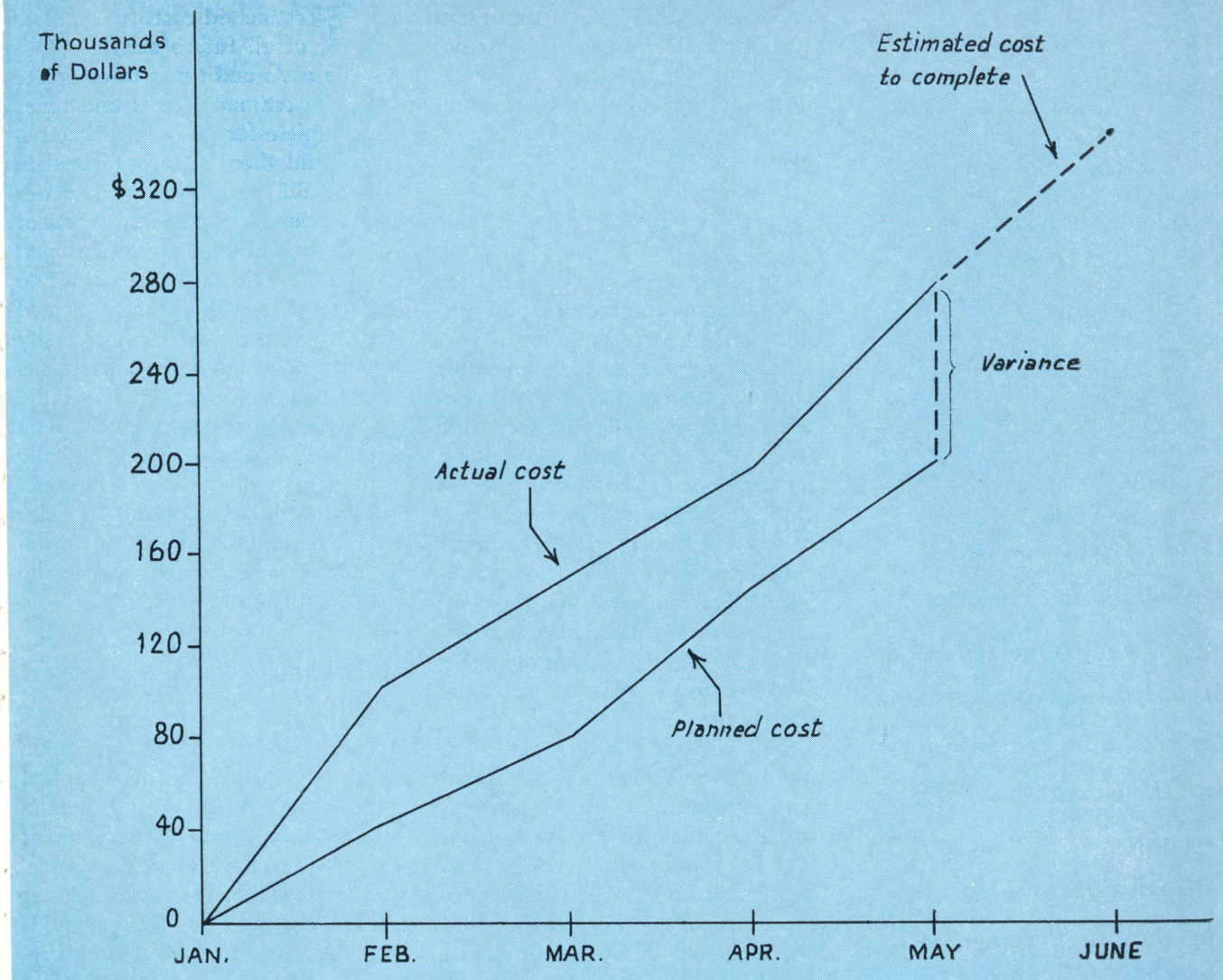

Figure 1
A Traditional Method of Determining
Contract Cost Variances

ernment work without some type of hedge; thus, both parties rely on the cost-plus contract.

Managers of highly technical and scientific projects have had difficulty in determining costs to complete during the execution of their projects and thus in evaluating the costs of the work already performed. The object of this article is to present a simplified method that may help solve some of these problems.

Traditionally, contractor performance evaluation has been accomplished by comparing actual costs incurred against planned costs over some period in time. Progress is then measured by the variances in these costs. This comparison does not tell the manager how close the project is to completion, nor does it give him information as to whether the costs incurred are parallel with the program's technical progress.

For example, let us assume that at a certain point in time the contractor has estimated total costs of $100,000 and reports his incurred costs to date are $85,000. With only this information, the determination of cost variances is derived as $15,000, which proves nothing. If the contractor has accomplished only one-half the work scheduled within the contractual period at a cost of $85,000, in reality the project is subject to an overrun. The contractor's projected overrun costs are approximately $70,000, which indicates poor performance

for determining variances in costs and cost to complete is illustrated in Figure 1 on page 25. Actual dollars spent and the actual costs of the accomplished work are compared and expressed in percentages.

An ideal method

An objective procedure for evaluating a contractor's performance on a job is not only a part of good business management for both the Government and the contractor but also an indispensable tool for determining incremental fee payments based on the value of work performed in contract terminations. Terminations of cost-plus contracts create some serious problems for the program management, not the least of them the fact that a position has to be determined for establishing the fee earned by the contractor.

The ideal method of determining the value of work performed and evaluating contract progress would be to have a computerized PERT program into which cost data could be inserted for all milestone activities; the results could be calculated easily, quickly, and accurately by the computer. A print-out sheet would show where the contract was in terms of lead or lag times in the scheduled event dates. However, to use PERT in the computerized form and justify its use to management, costs *must* be segregated by technical milestones and *must* include:

1. The actual time and cost to complete of each milestone activity and
2. The estimated times and estimated costs to complete of all future activities.

The costs and times to complete and the estimated costs and times to complete for downstream activities could then be incorporated in the PERT framework as a series of forecasts for the future costs of events within the major milestones. The milestone costs injected into the computer would be programed to give estimated future costs by month and quarterly increments for the downstream events of the program. Extrapolation of the data from the computer theoretically would give the manager financial and scheduling control. It also could be applied effectively in determining the earned fee to be paid to the contractor.

Difficulties

Unfortunately, if one tries to integrate PERT with companion costs in research and development programs, difficulties are encountered in determining the costs of milestone activities. For example, in the development of space booster rocket engines, the technology is unique, and information from previous engine development programs can not be used as a basis for establishing costs. Technical staffs find it impossible to prepare milestone cost estimates within an allotted time and still have them be usable as a management tool. Some of the events are parts of very small fragnets (subdivisions of a project network are called fragnets by NASA) and cannot be costed. Activities that are accomplished in one task are sometimes a common cost of other tasks, and these costs are impossible to differentiate. In many of the major tasks, milestone activities are too numerous for accurate estimation of costs with readily available and existing data. Costs of the master milestone activities (those events which have two or more paths leading into them) are difficult to determine—in most cases impossible.

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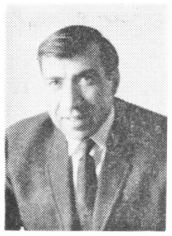

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FIGURE 2

XYZ CORPORATION
CONTRACTOR FINANCIAL MANAGEMENT REPORT — FORM 533

6. Reporting Category	7. Costs Incurred (000)		Estimated Cost to Complete (000)				9. Estimated Final Costs (000)	
	DURING MONTH	TO DATE	MONTH A	MONTH B	MONTH C	QUARTER D	CONTRACTOR ESTIMATE A	CONTRACT VALUE B
TOTAL NAS 3-2555 XYZ R&D	3,000	49,528	2,500	2,000	1,000	3,900	180,000	180,000
MAJOR TASKS								
TASK 2		3,552					32,196	
TASK 3		11,367					34,381	
TASK 5		2,555					6,235	
TASK 6		8,443					29,577	
TASK 7		14,600					33,860	

Estimating costs by events is difficult because of the simultaneous dependent activities within the master milestones.[3]

Reporting requirements

Contractors doing work for the Government are required to submit financial reports on program costs. The contractor's financial planning documents and the reporting procedures in most development programs are in different "financial semantics"; therefore, both the contractor and the project manager spend much time in eliminating differences in language rather than carrying out the role of financial management.

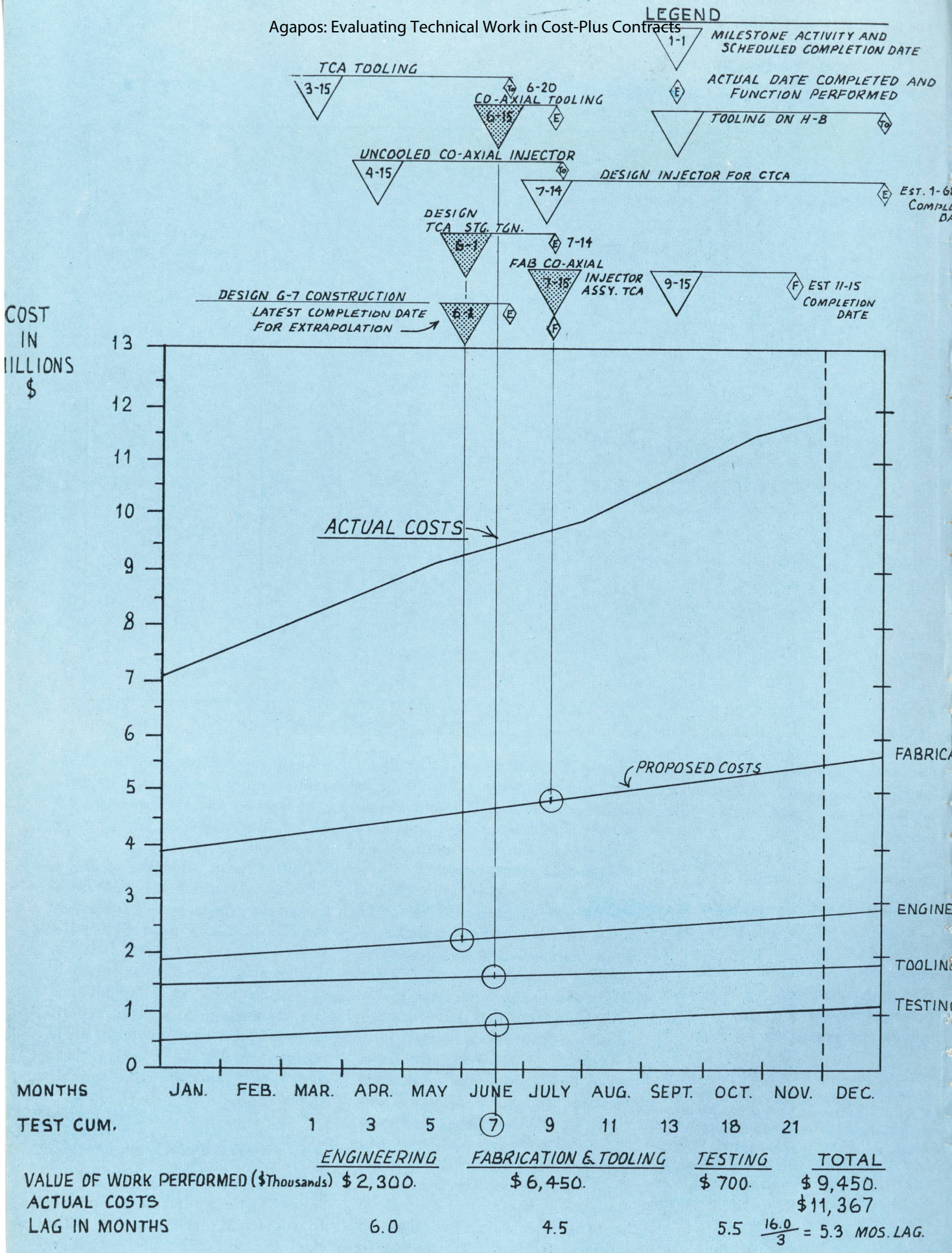
NASA uses a Contractor Financial Report, or Form 533, which is a contractual document oriented to show planned costs and estimated costs to complete. Basically, Form 533 requires the contractor to report his actual costs on a monthly basis and report his estimated costs to complete on a quarterly basis. After negotiations are completed and the proposal is issued, an initial Form 533, depicted in Figure 2 on this page, is submitted with a statement of the total costs that the contractor expects to incur. In the case illustrated in Figure 2 we see that the contractor plans to spend a total of $180 million to develop the XYZ engine. The $180 million represents the costs negotiated between the Government and XYZ Corporation for developing the engine.

Regardless of what the contractor's costs are at the completion of the engine development, whether they be $175 million or $220 million, the value received by the Government must be the original negotiated value of $180 million. We assume that no contractual amendments are made (such changes are highly unlikely) that decrease or increase the agreed value.

Assumptions and theory

Parallel with the submission of Form 533, the contractor is required to submit a schedular plan with the master milestone activities

[3] For an argument contrary to the method presented here, using a computerized PERT/Cost system based on management's ability to cost downstream milestones, see J. D. Walker and E. Houry, "A Comparison of Actual and Allocated Costs for Work Accomplished Using NASA PERT," *IEEE Transactions on Engineering Management*, Volume EM 12, Number 3, September, 1965, pp. 93-102.



	ENGINEERING	FABRICATION & TOOLING	TESTING	TOTAL
VALUE OF WORK PERFORMED ($Thousands)	$2,300.	$6,450.	$700.	$9,450.
ACTUAL COSTS				$11,367
LAG IN MONTHS	6.0	4.5	5.5	$\frac{16.0}{3}$ = 5.3 MOS. LAG.

Figure 3

TASK 3 THRUST CHAMBER ASS'Y.

identified. Also, he is required to submit a complementary PERT Master Plan, which becomes the criterion for assessing contract progress.

Refinements have been made by both Government and industry in the various PERT/Cost systems, but the general concept calls for development of a common framework for planning and controlling costs and schedules. The common framework for all aspects of project management is a work breakdown structure, whose major elements are established beginning with the highest levels of management and progressively broken down into smaller and smaller work packages until a desired control level is achieved. A complete project is divided into major systems, such as a power plant system and a space craft. A system such as a space craft is then subdivided into major subsystems, such as a control system and a thrust system, and the work breakdown continues to successively lower levels. Each subsystem or subdivision is categorized by functions such as engineering, fabrication, tooling, and testing, but the costs for these phases are reported by the contractor by task (see Figure 2).

A project is segregated into several smaller PERT networks, each of which has its own series of milestones. These smaller fragnets, or networks of tasks, in the aggregate make up major subsystems.

Theoretically, the completion of a master milestone at the task level indicates accomplishment of activities through that particular task. Once a position is determined for all major tasks that make up a system on a cost-plus-fixed-fee development contract, the value of work performed and that portion of the fee earned in relation to contractor performance can be determined.

Methodology

In most development contracts, the major milestones and completion dates can be taken from the contractor's original proposed plan (as is depicted in Figure 3 on page 28). Graphs are then developed for each of the major tasks that make up the aggregate project.

Transposing the costs from the planned cost curves for the major tasks, we can determine the value of work performed in relation to the actual costs incurred by the contractor. In the same step, the analyst can determine the lead or lag time for every major task and calculate a lead or lag time for the entire project.

Once the technical progress is determined in terms of milestone completions, actual costs are compared to what costs should have been as stated in the contractual agreement.

Management must realize that even this reporting method cannot solve the problem of activities that are carried out simultaneously. In other words, if three activities lead into a milestone and only two of the activities are complete, the value of work performed cannot be determined unless the technical manager determines and evaluates performance.

Employing the usual information provided in Government procurement, the technical manager can develop the value of work performed as follows:

TABLE I

VALUE OF WORK PERFORMED—XYZ ENGINE PROGRAM NOVEMBER 1967
(Cost in $ Thousands)

MAJOR TASKS	Value of Work Performed	Actual Costs Incurred	Time Lag in Months
Task 2 Engine Systems	$ 2,880	$ 3,552	5.0
Task 3 Thrust Chamber Assy.	9,450	11,367	5.3
Task 5 Gas Generator Assy.	2,000	2,555	6.0
Task 6 Oxidizer Turbopump Assy.	6,150	8,443	3.2
Task 7 Fuel Turbopump Assy.	11,690	14,600	3.4
TOTALS	$32,170	$40,517	22.9/5=4.6

With the above determinations, the analyst can derive the contractor's efficiency by dividing actual performance into actual costs.

$$\text{CONTRACTOR EFFICIENCY} = \frac{\$32{,}170 \text{ Value of Work Performed}}{\$40{,}517 \text{ Actual Contractor Costs}} = 79.4\%$$

Developing Value of Work Performed for the subordinate tasks is done by simple extrapolation, for example:

Subordinate Tasks	Costs Reported by Contractor
1	$3,106
8	2,525
9	983
10	255
11	365
12	1,056
13	117
14	169
Sub Total	$8,576
15	186
16	188
17	1
18	60
Sub Total	435
TOTAL	$9,011

MAJOR TASKS	Value of Work Performed	Actual Costs
	$32,170	$40,517
Subordinate Tasks (79.4% of $8,576 plus 100% of Tasks 15 through 18)	6,809	9,011
	435	
TOTAL	$39,414	$49,528

TABLE 2

SUMMARY OF COMPUTATIONS
The computations can be summarized as follows:
(Costs in $ thousands)

1. Value of work performed on XYZ engine development $39,414
2. Average lag on XYZ engine program ..... 22.9/5=4.6 mos.
3. Contractor efficiency 79.4%
4. Projected cost overrun for November to complete the contract, assuming the original proposed project costs were $180,000,000.

$$\left(\frac{\$18{,}000{,}000}{79.4\%\ \text{Efficiency}}\right) - \$180{,}000 = \$226{,}700 - 180{,}000 = \$46{,}700\ \text{projected overrun}$$

5. Actual overrun for November, 1965 ..... $49,528 − $39,414 = $10,114
6. Earned fee by contractor $= \frac{\text{FEE}}{\text{Development Costs}} = 7.4\%$

Assuming the value of work performed by the contractor is $39,414
X 7.4%, fee = ... $2,916
Fee paid to contractor to date 2,800
Fee to be paid to contractor ..... $ 116

7. Fee earned in terms of the contractor's progress is:

$$\frac{\text{Earned Fee}}{\text{Total Fee for Contractor}} = \frac{\$\ 2{,}916}{\$13{,}320} \times \frac{\text{Contract durations of}}{110\ \text{months}}$$

$$= .2189 \times 110\ \text{months} = 24\ \text{months}$$

8. Lag in months = duration of the contract − value of work performed in terms of progress.
Lag in months = 31 months (to date) − 24 months of performance in terms of value and accomplishment.
Lag in months = 7 months.

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1. The actual value of work performed is determined from the projected chart values on the basis of reported technical progress of the development of the research project.
2. The effectiveness of the contractor is determined by the formula:

$$\frac{\text{Actual Value of Work Performed}}{\text{Actual Cost of the Work}} = \text{— per cent}$$

Additional calculations can be based on the information submitted by the contractor, such as project lead or lag, overruns or underruns, and earned fee in increments and in terms of months of progress. These factors are shown as follows:

3. Contract average lag (or lead) time in months $=$

$$\frac{\text{Lead or Lag in Months}}{\text{Number of Major Tasks}}$$

4. The projected overrun $=$

$$\frac{\text{Contract Value}}{\text{Contractor Efficiency}} - \text{Contract Value}$$

5. The actual overrun or underrun $=$
Actual Costs − Value of Work Performed
6. The earned fee = Value of Work Performed × 7.4% fee, where:

$$\frac{\text{Total Fee}}{\text{Total Value of Contract}} = 7.4\%$$

7. The fee in terms of months of progress $=$

$$\frac{\text{Earned Fee}}{\text{Total Fee}} \times 110\ \text{months}$$

An example

In order to clarify the method, let us use Task 3, the Thrust Chamber Assembly, as an example of how the value of work performed versus the actual costs incurred is computed. Each proposed functional cost for testing, tooling, engineering, and fabrication is plotted annually for the Thrust Chamber Assembly. (See Figure 3.)

The actual costs reported by the contractor on Form 533 through November were $11,367,000. Totalling the value of work performed from the contractor's proposed cost from the graph in Figure 3 in dollars, a monthly calculation can be derived. (See the bottom of Figure 3). Using the identical procedure for the remaining tasks, a complete determination of value of work performed for the XYZ engine can be made. Substituting hypothetical data for the remaining tasks, we can develop a complete evaluation (see Table 1 on page 29).

The computations can be summarized as shown in Table 2 on this page.

Conclusion

Judgments regarding the validity of a contractor's costs and his actual costs and performance at any point in time are the responsibility of the program manager. To monitor costs successfully, he needs an effective management tool to supply him with information. Utilized correctly and with full understanding of the methods by both project and contractor management, the system described in this article can be used effectively to alleviate many of the initial problems encountered in technical programs.

This system eliminates time lags in project management data and serves to identify trouble areas in both the technical and financial divisions of technical projects. The approach is practical, quick, and inexpensive to implement. It can be used in conjunction with other management systems for greater control by an agency of the Government or by a Government contractor who wishes to establish his position in terms of schedules and fee payments on cost-plus contracts.

With experience, the basic approach should lead to refinements which will further simplify and clarify technical program management. The system can be tailored to individual programs by altering the mechanics, and some of the remaining loopholes can be closed through bargaining and negotiation.