



AGE

MARKINGS

REPORT SECURITY CLASSIFICATION
Unclassified

SECURITY CLASSIFICATION AUTHORITY
N/A

3. DISTRIBUTION / AVAILABILITY OF REPORT
Distribution Statement A: Approved for public release; distribution is unlimited.

DECLASSIFICATION / DOWNGRADING SCHEDULE
N/A

PERFORMING ORGANIZATION REPORT NUMBER(S)
NDU-ICAF-92- 160

5. MONITORING ORGANIZATION REPORT NUMBER(S)
Same

NAME OF PERFORMING ORGANIZATION
Industrial College of the Armed Forces

6b. OFFICE SYMBOL (if applicable)
ICAF-FAP

7a. NAME OF MONITORING ORGANIZATION
National Defense University

ADDRESS (City, State, and ZIP Code)
Fort Lesley J. McNair
Washington, D.C. 20319-6000

7b. ADDRESS (City, State, and ZIP Code)
Fort Lesley J. McNair
Washington, D.C. 20319-6000

NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (if applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS
PROGRAM ELEMENT NO. PROJECT NO. TASK NO. WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Productivity Measurement in Science and Technology Contracting

12. PERSONAL AUTHOR(S)
Thomas W. Mahler, Jr.

13a. TYPE OF REPORT
Research

13b. TIME COVERED
FROM Aug 91 TO Apr 92

14. DATE OF REPORT (Year, Month, Day)
April 92

15. PAGE COUNT
29

16. SUPPLEMENTARY NOTATION

| COSATI CODES | | |
|--------------|-------|-----------|
| FIELD | GROUP | SUB-GROUP |
| | | |
| | | |

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

SEE ATTACHED



20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
 UNCLASSIFIED/UNLIMITED SAME AS RPT. DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL
Judy Clark

22b. TELEPHONE (Include Area Code)
(202) 475-1889

22c. OFFICE SYMBOL
ICAF-FAP

ABSTRACT: "Productivity Measurement in Science and Technology Contracting." Thomas W. Mahler Jr., Lt Col, U. S. Air Force.

This paper demonstrates the feasibility of using traditional productivity measurement techniques to analyze the productivity of Science and Technology (S&T) contracting offices. S&T contracting offices are usually associated with the research laboratories of the Armed Services. It is important that these offices operate efficiently because current national security strategy emphasizes research as the primary means of maintaining technological superiority.

The author argues that simple, partial measures of productivity are the only practical tools for measuring the productivity of S&T contracting offices. The author develops a simple productivity measurement technique that is based on similar techniques used in industry. The technique is then demonstrated using real world data from the Air Force's Wright Laboratory contracting office.

1992
Executive Research Project
S60

Productivity Measurement in Science and Technology Contracting

Lieutenant Colonel
Thomas W. Mahler, Jr.
U. S. Air Force

Faculty Research Advisor
Lieutenant Colonel Robert A. Gustin, USAF



The Industrial College of the Armed Forces
National Defense University
Fort McNair, Washington, D.C. 20319-6000

98 3 29 002

93-06340



1992
Executive Research Project
S60

Productivity Measurement in Science and Technology Contracting

Lieutenant Colonel
Thomas W. Mahler, Jr.
U. S. Air Force

Faculty Research Advisor
Lieutenant Colonel Robert A. Gustin, USAF



The Industrial College of the Armed Forces
National Defense University
Fort McNair, Washington, D.C. 20319-6000

DISCLAIMER

This research report represents the views of the author and does not necessarily reflect the official opinion of the Industrial College of the Armed Forces, the National Defense University, or the Department of Defense.

This document is the property of the United States Government and is not to be reproduced in whole or in part for distribution outside the federal executive branch without permission of the Director of Research and Publications, Industrial College of the Armed Forces, Fort Lesley J. McNair, Washington, D.C. 20319-6000.

| Accession For | |
|--------------------|-------------------------------------|
| NTIS GRA&I | <input checked="" type="checkbox"/> |
| DTIC TAB | <input type="checkbox"/> |
| Unannounced | <input type="checkbox"/> |
| Justification | |
| By _____ | |
| Distribution/ | |
| Availability Codes | |
| Dist | Avail and/or Special |
| A-1 | |

DTIC QUALITY INSPECTED 1

This paper will explore the feasibility of using traditional productivity measurement techniques to measure the productivity of science and technology (S&T) contracting offices. The primary purpose of S&T contracting is to acquire research, and related goods and services, that are not directly associated with the engineering development of a specific system. Most S&T contracting is done by offices that are associated with the research laboratories of the Armed Services. S&T contracts are usually funded under accounts 6.1 (basic research), 6.2 (applied research), and 6.3A (large scale experimentation) of the DOD Research, Development, Test, and Evaluation budget. Additionally, there is contracting for specially funded programs like manufacturing technology research.

THE PROBLEM

Why should anyone be concerned about the productivity of S&T contracting offices? Two factors drive this concern. First, the current national security strategy of the United States puts unprecedented importance on the research work of the Service laboratories. Second, the Service laboratories are making significant efforts to streamline their acquisition procedures.

Consider the following statements from the 1992 National Military Strategy of the United States:

"The United States must continue to rely on technological superiority to offset quantitative advantages, to minimize risk to U. S. forces, and to enhance the potential for swift, decisive termination of conflict." (1)

"Beyond the requirement for reconstitution capability, is the compelling need for continued and significant R&D in a wide spectrum of technologies, applications, and systems." (2)

"Since we currently have the most technologically advanced systems in the world, our future investment choices may require

a different acquisition strategy than we have followed in the past. For example, full scale production may not always follow prototyping." (3)

These statements indicate that, for the foreseeable future, research will play a greater role than production in assuring U. S. technological superiority. This focus on research will put the laboratories in an unprecedented position of importance.

This new focus on the importance of research is occurring at the same time that the laboratories are engaged in extraordinary efforts to streamline their acquisition procedures. These efforts had their genesis in widespread criticism from sources like the 1983 White House Science Council (the so-called Packard Report); the Report of the Carnegie Commission on Science, Technology, and Government; and the House Armed Services Committee Workshop on Challenges Confronting the DOD Laboratories. Each of these sources identified inefficient acquisition procedures as a problem hindering the effectiveness of the laboratories.

The FY 1990 Defense Authorization Act created the Laboratory Demonstration Program. Congress established this program to encourage DOD to experiment with liberal new laboratory management policies in many areas including acquisition. The Services have responded to this program with initiatives to streamline contracting procedures.

Unfortunately, it is difficult to assess the impact of these streamlining initiatives. Contracting lead time might seem like an obvious way to measure this impact. But, a reduction in contracting lead time would not be a measure of improvement if the reduction was achieved by increasing the number of people working in the contracting office. Similarly, a decrease in contracting lead time that resulted from a decrease in workload would not be a measure of improvement. What is needed is a true productivity measurement technique. Such a technique should take into account the amount of work that is accomplished, the time required to accomplish the work, and the amount of labor that went into the work.

PREVIOUS RESEARCH

There is no standard way of measuring the productivity of a government contracting office. A literature search revealed only three previous studies that addressed the subject. Two of the studies focused on S&T contracting. A 1974 study by Richard B. Kennah suggested using a workload measurement system as a basis for measuring the productivity of what is now the Air Force's Wright Laboratory contracting office. (4) In 1983, Christopher D. Miller suggested using a computerized simulation of the S&T contracting process for the same purpose. (5) Productivity measurement was not the purpose of either study so neither author developed a productivity measurement technique.

A 1988 study by Steven Barclift and Desiree Linson evaluated the productivity of an Army contracting office that was not engaged in S&T contracting. (6) These authors satisfied their research objectives with empirical analysis. They made no attempt to develop a productivity measurement technique.

The literature search did not reveal any previous research that would be helpful in developing an S&T contracting productivity measurement technique. Therefore, the development of such a technique must rely on text books and studies that were written for activities other than contracting.

WHAT IS PRODUCTIVITY?

In order to develop a measure of productivity, it is necessary to understand what productivity is. In his book, the Productivity Improvement Manual, Alan Lawlor gives the following definition of Productivity:

"At its simplest, productivity is the relationship between goods produced and sold or services provided - the output, and the resources consumed in doing it - the input." (7)

Given this definition, the basic math of productivity measurement is very straight forward. It is simply output divided by input. The challenge of productivity measurement is to find measures of output and input that are both valid and relatively easy to obtain.

The primary reason that an organization measures productivity is to gauge the efficiency of the organization. Alan Lawlor points out four other uses of productivity measurement. These are determining the organization's success in achieving objectives, effectiveness in maximizing the use of resources, comparability with other organizations, and productivity trends over time. (8)

Problems arise if an organization attempts to use productivity measurement in an inappropriate way. Productivity measurement is not a substitute for cost accounting. It may use cost data, but it does not define the cost of producing goods or services. Productivity measurement is not a substitute for work measurement. It may use work measurement data, but it does not define the amount of labor that goes into a product. Additionally, productivity measurement does not identify the causes of problems. It may indicate that there is a problem, but other types of analysis are usually required to determine the cause of the problem. A good productivity measurement technique should focus on productivity and not on other issues.

PRELIMINARY QUESTIONS

Before developing a productivity measurement technique, two preliminary questions must be answered. First, can traditional productivity measurement techniques be used? Second, should total or partial productivity measures be used?

Traditional Measurement

Traditionally, productivity measurement is associated with manufacturing operations. Manufacturing operations are ideally suited for productivity measurement. There are usually a clearly defined set of products and a well understood set of processes required to build those products. These processes are often measured in great detail. As a result, records are usually available to show the resources that are consumed in the manufacture of products.

The growth of the service sector of the economy has created new challenges in productivity measurement. Service organizations may produce no tangible products, have no consistent work processes, and lack the ability to meaningfully measure resource consumption associated with providing specific services. Many attempts have been made to solve the problem of service sector productivity measurement. Organizations like General Electric, IBM, and the American Productivity Center have developed approaches to the problem. (9) In their previously mentioned study, Barclift and Linson referenced ten different approaches to service sector productivity measurement. (10) Unfortunately, no one has been able to develop an approach that has gained widespread acceptance.

In his book, A Practical Guide to Productivity Measurement, Leon Greenberg states that productivity measurement is not equally difficult for all types of service organizations. He points out that there are organizations, like barber shops, that produce highly tangible units of service. Speaking of such organizations, he states:

"Once the units of service are identified, the procedures for measurement are exactly the same as for a plant which manufactures commodities." (11)

An S&T contracting office produces tangible units of service. The output of an S&T contracting office is a set of types of contractual actions. These contractual actions result in a physical paper product, have a specific set of processes associated with their production, and the time consumed

by these processes is captured by a management information system. Given these conditions, it is appropriate to use traditional productivity measurement techniques to measure S&T contracting offices.

Total vs. Partial Measurement

One basic decision that must be made in developing a productivity measurement technique is determining the amount of information that is to be captured by the technique. In their book, Productivity by Objectives, James L. Riggs and Glenn H. Felix say that there are two possible approaches to the problem. One is to develop a total productivity measure that relates output to all associated inputs. The other approach is to develop a partial productivity measure that relates output to one type of input.

At first glance, total productivity measures are intellectually appealing. They appear to offer a more complete picture of the productivity of an organization. However, they are highly complex forms of measurement. They require the organization to measure every type of relevant input - labor, capital, materials, energy, and purchased services. Measuring all this input can be an overwhelming task. Additionally, the measurement technique can be so complex that it lacks intuitive meaning to the people in the organization. Riggs and Felix conclude:

"Calculating total productivity measure is an exhausting exercise. Judging from the survey reported earlier, not many companies undertake the exercise. Bypassing momentarily all the number crunching snags, the naked value of a total measure is still questionable." (12)

Partial productivity measures offer the possibility of obtaining a meaningful picture of organizational productivity in a way that is affordable. These measures may be thought of as being indicators, rather than complete measures, of productivity. Nevertheless, they are valuable tools. Riggs and Felix see great value in partial measures. They state:

"Well selected productivity indicators or partial measures furnish comparable information at less expense; expensive calipers are wasted where a cheap ruler is sufficient." (13)

It would be extremely difficult to develop a total productivity measure for an S&T contracting office. Government accounting procedures do not capture the cost of all the resources consumed by an S&T contracting office. There are no allocation procedures that capture the cost of the management or support structures in which the organization exists. Also, there are no depreciation techniques that allow the reasonable costing of capital expenditures. Given these limitations, the development of a partial productivity measure is the only viable alternative.

SURROGATES AND EQUIVALENTS

Key concepts in productivity measurement are the use of surrogates and equivalents. These concepts are particularly important in the use of partial productivity measures. The use of a surrogate simply means the use of a measure of output or input that approximates a measure that is too difficult to obtain. The use of equivalents means finding a measure that mathematically relates dissimilar factors that appear in either the output or input parts of the productivity equation.

The need for surrogates and equivalents becomes apparent when one considers that most organizations produce more than one product. If an organization produces a range of dissimilar products, it does little good simply to add up the total number of products produced and call the result output. There would be no understanding of the relative importance of each product.

Leon Greenberg suggests that a good solution to this problem is to define products in terms of the amount of labor associated with making the product. (14) The mathematical relationship between the amounts of labor associated with each product can then be used as a basis for making the products equivalent. For example, suppose that a plant produces two

products, Widget A and Widget B. Also, suppose that, on average, it takes one hour of labor to build Widget A and ten hours to build Widget B. In this case, one unit of Widget B would be the equivalent of ten units of Widget A. This relationship could be used to define the total output of the plant in terms of equivalent units. If the plant produced one Widget A and one Widget B, the total output would be eleven equivalent units.

The same approach can be used to measure input. If more than one category of worker is involved in producing a product, then the differences in cost of each category of labor can be used as a basis for equivalence. Input can then be measured in terms of equivalent units of labor. It should be noted that in using labor as a measure of input, the organization is trying to capture all the labor that is available for use. In using labor as a measure of output, the organization is trying to define products in terms of the standard amount of labor that it takes to produce one unit of each product.

DEVELOPING A MEASUREMENT TECHNIQUE

Using the concepts discussed above, it is possible to develop a productivity measurement technique for S&T contracting offices. The key to developing such a measure is finding valid equivalent measures of output and input.

Measuring Output

As previously discussed, S&T contracting offices produce a clearly defined set of products called contractual actions. These products are dissimilar. They vary in size, complexity, and the amount of work required for each. There is no work measurement system that measures, or approximates, the number of hours of labor that goes into each type of action. Therefore, labor hour content cannot be used to as a measure of output.

While S&T contracting offices do not capture the labor hours associated with contractual actions, their management information systems do capture the number of days that the contracting office spends working on each action. The average number of work days for each type of action can be used as a reasonable surrogate for the standard labor content of each action. The mathematical relationship between these standards can be used to develop equivalence relationships. The output of an S&T contracting office would be stated in terms of the number of equivalent contractual actions it produced.

Measuring Input

S&T contracting offices know the total number of employees assigned to the office. Therefore, they can use total available labor as a measure of the input of the organization. The size of the S&T contracting office work force could be stated in terms of the total hours of labor available. However, given that the labor hour content for each type of contractual action is not known, there would seem to be little benefit in defining input labor in terms of hours. It appears sufficient to state input in terms of the total number of employees in the organization.

The employees of S&T contracting offices comprise a wide range of military ranks and civilian pay grades. It is necessary to make these employees equivalent if they are to be used as a measure of input. This can easily be done by using the relative difference in the salaries of the different ranks and grades as a basis for equivalence. Using this approach, an employee with a higher salary would be measured as the equivalent of multiple employees with lower salaries. The final product of this approach would be measuring the input of an S&T contracting office as the total number of equivalent employees.

Accounting for Variance

It is extremely important that S&T contracting offices accomplish their work in a timely manner. The laboratories have been repeatedly criticized for slow acquisitions. The discussion above advocates using the

approximate average work days for each type of contractual action as a set of standards for measuring output. If this approach is used, then it is extremely important that the S&T contracting office's actual performance not be worse than the standards.

Actual performance is extremely important when viewed from the perspective of the S&T contracting office's customers. Performance standards that are measured in work days are essentially promises to complete contractual actions in the standard amount of time. A contractual action that is completed late is not the same thing as an action that is completed on time. The later a contractual action is, the worse it is. On the other hand, a contractual action that is completed early is a very positive thing.

The importance of timeliness means that variance from standard times must be taken into account when measuring productivity. Fortunately, this can be done in a straight forward way. The S&T contracting office's management information system captures actual performance on all contractual actions. These actuals can be used to compute variance on all actions. This variance can be subtracted from, or added to, the standards to adjust the measure of output according to whether the S&T contracting office's performance was either negative or positive.

A REAL WORLD APPLICATION

The discussion above presented a theoretical basis for developing a measure of S&T contracting office productivity. The actual application of these concepts is not difficult. The discussion below will use these concepts to analyze the productivity of the Wright Laboratory contracting office in FY 1990 and FY 1991. (15) Wright Laboratory is the Air Force's largest laboratory. Its contractual workload is approximately equal to the combined workload of the Air Force's other three laboratories.

Output

The Wright Laboratory contracting office produces five basic types of products. These are: Phase I Small Business Innovative Research (SBIR I) awards, Phase II Small Business Innovative Research (SBIR II) awards, Program Research and Development Announcement and Broad Agency Announcement (PRDA/BAA) awards, awards using Request For Proposal (RFP) procedures, and modifications (MODs) to contracts that have previously been awarded.

Wright Laboratory has developed standards for the amount of time it should take to accomplish each type of action. The standards are stated in terms of the number of calendar days that pass from the day of receipt of a purchase request to the day of contract award. They are based on the actual historical performance of top performing Air Force laboratories. These standards are: SBIR I - 30 days, SBIR II - 107 days, PRDA/BAA - 90 days, RFP - 160 days, and MODs - 60 days. These standards are reasonable surrogates for the labor content of contractual actions and can be used as measures of output.

Since the standards are stated quantitatively, it is not difficult to make them equivalent. It is simply a matter of selecting one of the standards as a baseline and dividing all the other standards by the baseline standard. The result is a set of numbers that defines each type of contractual action in terms of the equivalence of each to the baseline contractual action. It makes little difference which standard is used as the baseline. But, there is some intuitive logic in using the type of contractual action that comprises the largest part of the workload of the contracting office. With this approach, the baseline would represent the largest single block of work accomplished by the organization.

Using the approach described above, it is easy to measure the output of the Wright Laboratory contracting office. The table below shows that output for FY 1990. Column 1 shows the type of contractual action. Column 2 shows the standard time to accomplish each action. Column 3 shows the equivalence of each type of contractual action to the baseline action.

Contract modifications were chosen as the baseline type of action because they are the largest portion of the contracting office's workload. Column 4 shows the actual number of actions of each type that were accomplished in FY 1990. Column 5 shows the equivalent number of actions of each type that were accomplished. Column 5 is simply the actual number of actions multiplied by the equivalence factor.

| <u>TYPE ACTION</u> | <u>STANDARD</u> | <u>EQV FACTOR</u> | <u># ACTIONS</u> | <u>EQV ACTIONS</u> |
|--------------------|-----------------|-------------------|------------------|--------------------|
| MODs | 60 | 1.00 | 523 | 523.00 |
| SBIR I | 30 | .50 | 92 | 46.00 |
| SBIR II | 107 | 1.78 | 35 | 62.30 |
| PRDA/BAA | 90 | 1.50 | 132 | 198.00 |
| RFP | 160 | 2.66 | <u>146</u> | <u>388.36</u> |
| Totals | | | 928 | 1,217.66 |

The table below shows output for FY 1991.

| <u>TYPE ACTION</u> | <u>STANDARD</u> | <u>EQV FACTOR</u> | <u># ACTIONS</u> | <u>EQV ACTIONS</u> |
|--------------------|-----------------|-------------------|------------------|--------------------|
| MODs | 60 | 1.00 | 592 | 592.00 |
| SBIR I | 30 | .50 | 82 | 41.00 |
| SBIR II | 107 | 1.78 | 50 | 89.00 |
| PRDA/BAA | 90 | 1.50 | 155 | 232.50 |
| RFP | 160 | 2.66 | <u>68</u> | <u>180.88</u> |
| Totals | | | 947 | 1,135.38 |

The tables above tell an interesting story about the output of the Wright laboratory contracting office in FYs 1990 and 1991. The office produced 19 more actual contractual actions in FY 1991. Yet, there were 78 fewer awards made using RFPs. Since these are the contracting office's most complex and time consuming products, the number of equivalent actions fell by 82.28.

Variance

The figures above do not present an accurate picture of the real difference in the productivity of the contracting office between FY 1990 and 1991. They do not show the difference in the speed of contractual action execution that the contracting office achieved in FY 1991. That was the first year of implementation of the Laboratory Demonstration Program. The laboratory launched a major effort to speed up the execution of contractual actions. The results of this effort were impressive. Those results illustrate why variance from standards must be incorporated into measuring an S&T contracting office's productivity.

Incorporating variance into the productivity measure is not difficult. The table below shows how it can be done using Wright Laboratory's FY 1990 data. Column 1 shows the type of contractual action. Column 2 shows the standard work days for each type of action. Column 3 shows the actual number of actions of each type that were accomplished. Column 4 shows the actual number of actions multiplied by the standard for each type of action. The numbers in column 4 represent the total number of work days of effort that would have been expended on each type of action if all actions had been accomplished in the standard amount of time. Column 5 is the actual number of workdays that were expended on each type of action. The difference between column 4 and column 5 is the total variance between the number of work days that should have been expended on the contracting offices work load and the number of work days that were expended. For FY 1990, this was a large negative variance. If this negative variance is divided by the baseline standard of 60 days, the result is the

number of equivalent actions that this negative variance represents. Thus, negative variance could be considered negative equivalent actions.

| <u>TYPE ACTION</u> | <u>STANDARD</u> | <u># ACTIONS</u> | <u>STD TIME</u> | <u>ACTUAL TIME</u> |
|--------------------|-----------------|------------------|-----------------|--------------------|
| MODs | 60 | 523 | 31,380 | 31,903 |
| SBIR I | 30 | 92 | 2,760 | 9,016 |
| SBIR II | 107 | 35 | 3,745 | 3,955 |
| PRDA/BAA | 90 | 132 | 11,880 | 18,480 |
| RFP | 160 | 146 | <u>23,360</u> | <u>36,938</u> |
| Totals | | | 73,125 | 100,292 |
| Variance | | | | -27,167 |

If the negative equivalent actions of -27,167 days is divided by the baseline standard of 60 days, the result is 452.78 negative equivalent actions. Earlier calculations showed a production of 1,217.66 equivalent actions in FY 1990. However, this number was not weighted for variance. It is apparent that, in FY 1990, the contracting office fell behind desired standards by more than a third. The figure of 452.78 negative equivalent actions reflects this fact. If these 452.78 negative equivalent actions are subtracted from the 1,217.66 unweighted equivalent actions, the result is 764.88 weighted equivalent actions. This figure is a more realistic measure of the output of the Wright Laboratory contracting office in FY 1990. It reflects serious negative impact of finishing behind standard times on every category of contractual action.

The work day standards used in the calculations above were adopted by Wright Laboratory late in FY 1990. There was little chance that the contracting office could conform to the standards in that fiscal year. They

were established primarily as a baseline for measuring future performance. In FY 1991, the laboratory experienced the benefits of a vigorous Total Quality Management program and the Laboratory Demonstration Program. There was a dramatic improvement in the time required to execute contractual actions. This improvement is reflected in the table below.

| <u>TYPE ACTION</u> | <u>STANDARD</u> | <u># ACTIONS</u> | <u>STD TIME</u> | <u>ACTUAL TIME</u> |
|--------------------|-----------------|------------------|-----------------|--------------------|
| MODs | 60 | 592 | 35,520 | 33,744 |
| SBIR I | 30 | 82 | 2,460 | 1,804 |
| SBIR II | 107 | 50 | 5,350 | 2,850 |
| PRDA/BAA | 90 | 155 | 13,950 | 12,090 |
| RFP | 160 | 68 | <u>10,880</u> | <u>9,384</u> |
| Totals | | | 68,160 | 59,872 |
| Variance | | | | 8,288 |

As these calculations demonstrate, the Wright Laboratory contracting office went from a substantial negative variance in FY 1990 to a positive variance in FY 1991. This positive variance represents a real increase in mission accomplishment for both the contracting office and the laboratory as a whole. Dividing the 8,288 day positive variance by the 60 day standard baseline results in a positive variance stated as 138.13 equivalent actions. Earlier calculations showed a production of 1,135.38 unweighted equivalent actions in FY 1991. By adding the impact of positive variance, the result is a figure of 1,273.51 weighted equivalent actions. This figure reflects a meaningful increase in the output of the contracting office.

All calculations so far have been presented using tables. Tabular presentations have been used because they make it easier to follow the

development of the numbers. Actually, it is possible to compute total unweighted equivalent actions without using the equivalence factors used in the first two tables. Unweighted equivalent actions can be computed directly from the total standard times shown in the third and fourth tables. The only necessary calculation is to divide the total standard time by the baseline standard of 60 days. For FY 1990, this would mean dividing the total standard time of 73,125 days by 60 for a result of 1,218.75 equivalent actions. For FY 1991, the calculation would be 68,160 days divided by 60 for a result of 1,136 equivalent actions. The results are slightly higher for the simplified calculations because of the greater rounding error in the tabular calculations.

Weighted equivalent actions are similarly easy to calculate directly. Weighted equivalent actions are equal to:

$$\frac{\text{Total Standard Time} + (\text{Total Standard Time} - \text{Actual Time})}{\text{Baseline Standard}}$$

Applying this formula to the FY 1990 figures would yield:

$$\frac{73,125 + (73,125 - 100,292)}{60} = 765.97 \text{ Weighted Eqv Actions}$$

Applying this formula to the FY 1991 figures would yield:

$$\frac{68,160 + (68,160 - 59,872)}{60} = 1,274.13 \text{ Weighted Eqv Actions}$$

The formulas shown above are the quickest way to compute weighted equivalent actions. Again, the results are slightly higher because of the rounding error associated with the tabular presentation. These formulas are very easy to use in conjunction with S&T contracting management information systems. Since weighted equivalent actions are the most desirable measure of output, these formulas should be used to compute directly the output of an S&T contracting office.

Input

The Wright Laboratory contracting office is the largest S&T contracting office in the Air Force. In FY 1991, the office was authorized to have 185 employees. The payroll cost of these employees is many times larger than the contracting office's expenditures for all other purposes. The high relative cost of employees makes labor an extremely good measure of input.

The most intuitively logical way to measure input labor is in terms of number of employees. If total weighted equivalent actions are divided by the number of employees, the result is a measure of productivity that is defined as the number of equivalent actions per employee. This definition appeals to common sense. Use of other surrogates for measuring input would have less intuitive appeal. If input were defined in terms of labor hours or dollars, the result would be a measure of equivalent actions per hour or dollar. These measures would result in very small fractional numbers that convey little intuitive meaning.

Given that number of employees is the best measure of input, the problem of equivalence must be resolved. The Wright Laboratory contracting office's FY 1991 personnel authorizations by grade and rank are as follows:

| <u>Military</u> | <u>Civilian</u> |
|-----------------|-----------------|
| LTC - 2 | GM15 - 1 |
| Maj - 3 | GM14 - 5 |
| Cpt - 10 | GM13 - 13 |
| 1lt - 4 | GS13 - 15 |
| Msgt - 1 | GS12 - 69 |
| Amn - <u>3</u> | GS11 - 9 |
| 23 | GS7 - 2 |
| | GS6 - 10 |
| | GS5 - <u>35</u> |

162

This diverse mix of personnel emphasizes the need for equivalence. One approach to equivalence would be to develop equivalence factors for all grades and ranks of employees. This could be done by using the standard salary of the grade with the largest number of employees as a baseline and dividing the salary of all other grades and ranks by the baseline salary. By doing this the work force could be defined in terms of an equivalent number of the largest group of employees.

The equivalence factor approach has drawbacks. The number of people that actually work for a contracting office fluctuates continuously. Personnel authorizations change in reaction to changes in mission and

workload. Employees retire, move to other jobs, and take extended leaves to pursue education. Budget limitations often prevent hiring against vacant authorized positions. This personnel turmoil would make it extremely difficult to maintain a system of equivalence factors. It could be done, but it would require monthly adjustments to compensate for work force fluctuations.

It would be extremely difficult to reconstruct equivalence factors for the Wright Laboratory contracting office for FYs 1990 and 1991. During those two years, the contracting office began drawing down support of one major customer while simultaneously adding a new geographically separated branch to support a new customer. The office also experienced unanticipated military moves and employees that were on extended absences because of illnesses or full time training.

Fortunately, there is a simple way to compute equivalent employee head count without using equivalence factors. It is easy to obtain actual expenditures for employee pay. If total employee pay is divided by a baseline salary, the result is the number of equivalent employees that were actually compensated. This approach results in an equivalent head count that is both accurate and easy to compute.

Total salary costs for the Wright Laboratory contracting office were \$5.921 million in FY 1990 and \$7.251 in FY 1991. The largest single pay grade of employees during both years was GS12. The government pay tables provide a standard salary for a mid-step GS12. This salary was \$40,640 in FY 1990 and \$42,306 in FY 1991. Using these figures, the equivalent head counts for FY 1990 and 1991 can be computed as follows:

$$\text{FY 1990} - \frac{\$5.921 \text{ Million}}{\$40,640} = 145.69 \text{ Eqv Employees}$$

$$\text{FY 1991} - \frac{\$7.251 \text{ Million}}{\$42,306} = 171.39 \text{ Eqv Employees}$$

These numbers of equivalent employees are a good surrogate for measuring labor input. They are a valid basis for computing productivity.

Productivity

At this point, measuring productivity is a very straight forward procedure. It is simply a matter of dividing the measure of output - weighted equivalent contractual actions, by the measure of input - equivalent employees. The calculations are as follows:

$$\text{FY 1990} - \frac{765.97}{145.69} = 5.26 \text{ Eqv actions per Eqv employee}$$

$$\text{FY 1991} - \frac{1274.13}{171.39} = 7.43 \text{ Eqv actions per Eqv employee}$$

It is also a straight forward procedure to calculate the change in productivity between FYs 1990 and 1991. The calculations are as follows:

$$\frac{7.43 - 5.26}{5.26} \times 100 = 41.25\%$$

The calculations above provide a valid measure of the productivity of the Wright Laboratory contracting office in FY 1990 and 1991. They take into account complex interrelationships between changes in workload, employment levels, and speed of contractual action execution. They are based on easily obtainable numbers and simple mathematics. They demonstrate that Wright Laboratory achieved a significant increase in contracting office productivity in FY 1991.

SUMMARY

This paper has demonstrated a relatively simple technique for measuring the productivity of S&T contracting offices. Using the terminology of Riggs and Felix, this technique is a cheap ruler rather than an expensive caliper. Nevertheless, the technique should prove sufficiently robust to accommodate large differences in work load and employment level. Individual S&T contracting offices should be able to adopt the technique without too much difficulty. Adopting the technique at the Service or DOD level would require development of Service-wide or DOD-wide standards for the number of days required to execute various types of S&T contractual actions. Given the abundance of management information system data that is available, this should not be too difficult a task.

The proposed productivity measurement technique does a good job of measuring the efficiency of S&T contracting offices. The technique does not answer all the questions that might be asked about the functionality of an S&T contracting office. It does not define the maximum output capabilities of a given office. Therefore, it cannot be used to gauge a contracting office's productivity relative to what it is capable of doing. The technique does not involve cost data. Therefore, it cannot be used to analyze the costs associated with executing contractual actions. These additional questions may be matters of valid concern. But, answering them will require the development of work measurement and accounting systems that do not exist. Developing such systems would be major undertakings that would require large commitments of time and resources. The proposed approach

provides a basic measure of productivity that is intuitive, easy to compute, and based on data that is available now.

It is recommended that the Air Force incorporate the proposed productivity measurement technique into its system of measuring the performance of S&T contracting offices. The Air Force should take the lead because this paper has proven that the proposed technique is easily implemented using the Air Force's existing S&T contracting management information system. The results of the Air Force implementation of the technique should be reviewed by the OSD team responsible for implementation of the Laboratory Demonstration Program contracting initiatives. If the results of the Air Force implementation are favorable, then the technique should be considered for DOD-wide implementation.

NOTES

1. Joint Chiefs of Staff. National Military Strategy of the United States. Washington: U. S. Government Printing Office, January, 1992. p. 10.
2. Ibid., p. 25.
3. Ibid., p. 25.
4. Kennah, Richard B., "The Measurement of Procurement Workload." Master's thesis. School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB, Ohio. September, 1974. p. 52.
5. Miller, Christopher D., "Q-Gert Model of the Contracting Cycle." Master's thesis. School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB, Ohio. September, 1983. p. 27.
6. Barclift, Steven C. and Linson, Desiree D., "Impact of Office Automation: An Empirical Assessment." Master's thesis. Naval Postgraduate School, Monterey, California. December, 1988. p. 1.
7. Lawlor, Alan. Productivity Improvement Manual, Westport, Connecticut: Quorum Books, 1985. p. 8.
8. Ibid., p. 36.
9. Lehrer, Robert N., White Collar Productivity. New York: McGraw-Hill Book Company, 1983.
10. Barclift and Linson. "Impact of Office Automation: An Empirical Assessment." pp. 3-17.
11. Greenberg, Leon. A Practical Guide to Productivity Measurement. Washington: Bureau of National Affairs, Inc., 1973. p. 40.

12. Riggs, James L. and Felix, Glenn H., Productivity by Objectives. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1983. pp. 68-69.

13. Ibid., p. 69.

14. Greenberg, Leon. A Practicle Guide to Productivity Measurement. p. 18.

15. All data used in this paper was obtained by the author from the Wright Laboratory contracting office. Main points of contact were Mr. Chris Miller, Mr. George Rogers, and Mr. Jim Marcellus. Additionally, the author obtained standard salary data and actual salary expense data from Ms Marsha Kerns of the Wright Laboratory comptroller office.