

What Every Engineer Should Know / 6

**WHAT EVERY  
ENGINEER SHOULD  
KNOW ABOUT**

# **MANUFACTURING COST ESTIMATING**

**Eric M. Malstrom**

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# **What Every Engineer Should Know About Manufacturing Cost Estimating**

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**What Every Engineer  
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Manufacturing Cost Estimating**

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## Preface

The purpose of this book is to document techniques for the generation of "grass roots" cost estimates, cost reviews, and cost forecasts. This material is necessary background for industrial engineers, manufacturing engineers, design engineers, production planners, shop schedulers, and manufacturing managers. College students enrolled in programs of industrial engineering, manufacturing engineering, and industrial technology also require a knowledge of these subjects.

The thrust of this book is toward manufacturing, with an emphasis on metal working and electronic fabrication/assembly. Although I have included chapters which address construction estimating and estimating the costs of engineering design, readers with primary interests in these areas may wish to consult other available literature which addresses these topics in more detail.

I have taken steps to make this book easily applicable to actual cost estimating situations. Considerable time and effort have been spent constructing the detailed numerical examples which appear in Chapters 3 and 5-8. Readers will find it beneficial to review this material slowly, perhaps with a notepad and calculator at hand to aid in following the illustrated sequences of numerical examples. Precise mathematical notation has been used to describe the cost forecasting method presented in Chapter 8. The notation and subscripts were necessary for those readers who intend to utilize this system on a computer.

With the exception of Chapter 8, all other chapters contain relatively straightforward material for most readers. The latter chapters utilize and draw on material presented in the first part of the book. As a result, it is my recommendation that the chapters be read in the order in which they are presented.

Eric M. Malstrom

## **About the Author**

Eric M. Malstrom is an Associate Professor of Industrial Engineering at Iowa State University, Ames, Iowa. He has held a previous engineering faculty position at the University of Cincinnati and has held a variety of engineering and manufacturing positions at the Naval Avionics Center, Indianapolis, Indiana. Dr. Malstrom received a B.S. degree in electrical engineering, an M.S. degree in industrial operations, and a Ph.D. degree in industrial engineering from Purdue University. He is a member of the American Association of Cost Engineers, the American Institute of Industrial Engineers, and Society of Manufacturing Engineers. Dr. Malstrom has served as a professional consultant to industry, government municipalities, and legal organizations. He has written numerous publications and papers and is a registered professional engineer.

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# 1

## **Nature of the Cost Estimating Process**

### **1.1 INTRODUCTION**

*Cost estimating* may be described as the process by which a forecast of costs required to manufacture a product or complete a specified task is made. Gallagher (1965) has stated that this task consists of calculating and projecting the future costs of men, materials, methods, and management. The degree of accuracy with which estimates are made is dependent primarily on two parameters: (1) the degree of design or project definition available at the time the estimate is to be made, and (2) the amount of time available in which to make the estimate.

If the design of a product is complete and not subject to future change, parts and raw materials to be purchased are not subject to variation. If the precise production quantity is known prior to making the estimate, methods and techniques of production may be anticipated with a considerable degree of accuracy. Park (1973) has indicated that the accuracy of the cost estimate is directly proportional to the amount of money the company (or its client) is willing to spend. The more accurate the estimate, the more time required for its preparation.

This book will primarily address the cost estimating task associated with the manufacturing function. However, extensions of the manufacturing estimating process to construction and engineering research projects will be considered in later chapters. It will be shown that the manufacturing estimating process is the most complex of the three procedures.

The intent of this chapter is to describe the historical role of the engineer in the cost estimating process. Some space will be devoted to describing job experience and backgrounds that characterize personnel that typically compile cost estimates for manufacturing. Progress that has been made to date in

quantifying steps in the estimating process will be summarized. Finally, a brief description of the manual part of the cost estimating process will be given.

## **1.2 THE HISTORICAL ROLE OF THE ENGINEER IN THE COST ESTIMATING PROCESS**

Historically, the role of most engineers in the cost estimating process has been limited. Engineers in their formal education usually receive little or no training in this area. This may be because this subject is difficult to teach at the college level. The obtaining of a working, thorough knowledge of cost estimating requires an appreciable amount of "hands-on" experience which is best obtained in a production environment. Since many academicians are not afforded the opportunity to obtain such experience, this subject area often receives little or no attention in many academic programs.

Engineers often become aware of the importance of the cost estimating function after 1 to 2 years of full-time employment. Manufacturing cost estimators must be intimately familiar with not only the entire range of products produced by the organization, but with all of the physical production facilities used in product manufacturing. While many engineers are able to familiarize themselves with the types of products produced, the nature of many engineering positions prevents many personnel from obtaining detailed knowledge of production processes and techniques.

The need for engineers to understand facets of the estimating process is of paramount importance. While most engineers never obtain enough production experience to make cost estimates by themselves, many learn enough about cost-quantity relationships and alternate production procedures to specify sound, cost-effective designs. With continued professional growth, some engineers assume management positions within the manufacturing organization. These individuals must often assume direct or indirect supervisory responsibilities for cost estimating work sections or groups.

## **1.3 EXPERIENCE AND BACKGROUNDS OF COST ESTIMATING PERSONNEL**

Engineers routinely engage in the task of estimating the costs of design and development of products and research; but they do not always realize that estimating for the manufacturing function is a more lengthy and complicated task. Manufacturing cost estimators are often characterized as individuals that have worked within the organization for a considerable period of time. Estimators frequently have no formal academic training beyond the high-school level. Some obtain post-high-school training through 2-year technical programs. Such training is usually obtained on a concurrent basis with full-time employ-



ment commitments. Many estimators make a blue-to-white collar transition from a shop position to that of a cost estimator at a midpoint in their career. Such moves often occur after 5 to 15 years of prior experience in various positions in the machining and/or assembly divisions of the manufacturing department.

In compiling cost estimates for manufacturing, estimators are required to draw on a wealth of knowledge that can only be obtained after years of production work experience. Cost estimators need to be intimately familiar with the entire range of products produced by the organization. An intimate familiarity with physical production facilities is also required. Estimators must be able to specify or anticipate the processes required for the manufacture of specific products. In addition, the proper sequence of such processes must be known. Such sequences may vary even for identical products, particularly as production quantities vary.

#### 1.4 PROGRESS MADE IN QUANTIFYING THE ESTIMATING PROCESS

The progress that has been made to date in quantifying and automating steps of the estimating process has not been overwhelming. In fact, most of the estimating processes for manufacturing remain manual processes. This lack of progress can be attributed to two factors. First, most personnel that currently make manufacturing cost estimates lack many of the analytic skills necessary to develop mathematical models or to utilize the computer in improving the productivity of this process. Second, the process has historically received minimal attention from those engineering personnel with the skills necessary to make such improvements. It should be pointed out that the problem of automating the estimating process is one of extreme complexity. The number of variations in product configurations together with the degree of finesse necessary to make consistently accurate estimates may forever prevent the process from becoming completely automated.

In spite of these difficulties some progress has been made. For an initial cost estimate that has been made by conventional methods, Malstrom (1976) has developed an algorithm that forecasts potential projects costs once the project commences and begins to progress through various stages of completion. The PRICE algorithm, developed by Freiman (1975), has been shown to be a useful check on the accuracy of a cost estimate after it has been completed. The algorithm is usable primarily for electronics production and predicts total cost on a basis of production lot size, number of components, component density, and other variables. Work has also been done to facilitate the determination of costs of purchased parts for a manufactured item. Computer storage for price retrieval is utilized. However, the part must have been previously