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LOGISTICS ENGINEERING AND MANAGEMENT

Benjamin S. Blanchard

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2nd edition

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Dedicated to my wife, DOROTHY,
my children, BECKY, BENJAMIN, *and* LISA,
for their tolerance
and encouragement in this endeavor.

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PREFACE

Logistics is by no means a new subject area. Historically, the concept of logistics stems from specific facets of military and industrial management. In the military sense, logistics is concerned with the various aspects of maintenance and system/product support, particularly from the point in time when systems are in operational use. In the industrial or commercial sector, logistics has been defined to include such activities as material flow, product distribution, transportation, warehousing, and the like. In both situations, however, logistics has been considered as a "downstream" effort, and the requirements for logistics have not been very well defined or integrated.

In recent years, systems and products have become more complex as technology advances, and logistics requirements have increased in general. Not only have the costs associated with system/product acquisition increased significantly in the past decade, but the costs of logistic support have also been increasing at an alarming rate. At the same time, the current economic dilemma of decreasing budgets combined with upward inflationary trends results in less money available for both the procurement of new systems and for the maintenance and support of those items already in use.

In view of these trends, one of the greatest challenges facing industry, businesses, government agencies, and the general consumer of products and services today is to meet the growing need for more effective and efficient management of our resources. The requirement to increase overall produc-

tivity in a resource-constrained environment has placed emphasis on *all* aspects of the system/product life cycle, and logistics has assumed a major role comparable to research, design, production, and system performance during operational use. The need to address total system life-cycle cost (in lieu of acquisition cost only) is evident, and experience has shown that logistic support is a major contributor to life-cycle cost. Further, experience has indicated that a great deal of the impact on the projected life-cycle cost for a given system or product stems from decisions made during the early stages of advance system planning and conceptual design. Decisions at this point have a major effect on activities and operations in all subsequent phases of the life cycle. Given the "cause and effect" relationships and the fact that logistics costs may assume major proportions, it is essential that logistic support be considered (as part of the decision-making process) in the early phases of system/product planning and design.

In essence, logistics, which includes the integration of many activities and elements, has become significant in each phase of the life cycle. Logistics requirements must be initially planned and subsequently integrated into the system/product design process. The ultimate objective is to develop, produce, and operate a system incorporating the necessary logistic support capability both effectively and efficiently.

The purpose of this book is to provide a new emphasis in logistics—the emphasis on logistics in the total system design and development process. The design of a system or product for supportability has a tremendous impact on what resources will later be required to support that system. Through the proper planning and emphasis on logistics early in the system life cycle, the necessary characteristics can be incorporated to ensure that the resultant product can be effectively and economically supported from the time that the product is initially introduced until retirement and phase-out occurs. Logistic support should be a major consideration in the establishment of system requirements, in the development of design criteria, and in the evaluation of alternatives leading to the selection of a firm design configuration. The object is to develop a system that will fulfill its mission at the lowest overall life-cycle cost.

This book provides an introduction to logistics engineering and management, and the material presented herein may be categorized in three basic areas. Chapters 1 and 2 focus on the language, definitions, principles, and some of the quantitative measures of logistics used in prediction and analysis. Coverage includes systems engineering, cost/system effectiveness, reliability and maintainability, and the application of statistical techniques in logistics. These chapters constitute an introduction to the subject matter. Chapters 3 through 10 apply the principles of logistics to the system/product life cycle commencing with the identification of a need and extending through system operational use and ultimate retirement. These chapters are presented in the

order of progression one would expect in the development and use of a system (i.e., definition of operational requirements and maintenance concept, system functional analysis, detail design and development, test and evaluation, production or construction, and operational use). As the reader progresses through the text, he or she should be able to readily apply the principles of logistics to a real world situation. Finally, Chapter 11 presents a total management overview covering all phases of a program and integrating the functions discussed in the earlier chapters. Although management is inherent throughout the book, Chapter 11 emphasizes the major considerations involved.

This book is designed for use in the classroom (at either the undergraduate or graduate program levels) or by the practicing professional in industry, business, or government agency. The concepts and techniques presented are applicable to any type of system, and the functions discussed may be "tailored" to meet the needs of both large- and small-scale programs. Many practical problems are introduced, and numerous excellent references are included. In addition, the text material is arranged in such a manner as to guide the practicing engineer on a day-to-day basis in the performance of his or her job, and to serve as an authoritative source for those in management who must direct and control logistic support activities.

I wish to thank Dr. Wolter J. Fabrycky, Dean of the Research Division, Virginia Tech, for his encouragement in the preparation of this text, and Mr. Elmer L. Peterson (Teledyne Ryan Aeronautics) and Mr. William Rogers (Martin Marietta-Denver Division) for their review and comments associated with the text material.

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INTRODUCTION TO LOGISTICS

A "system" may be considered to be a nucleus of elements structured in such a manner as to accomplish a function to satisfy an identified need.[1] The elements of a system include all equipment, related facilities, material, software, data, services, and personnel required for its operation and support to the degree that it can be considered a self-sufficient entity in its intended operational environment, throughout its planned life cycle. Logistics relates to the support of a system and includes the elements of test and support equipment, supply support, personnel and training, transportation and material handling, special facilities, data, and so on, necessary for the accomplishment of material flow and distribution functions, as well as the sustaining life-cycle maintenance support of the system throughout its period of use.

In the development of systems, the past has been replete with instances where the prime equipment has been designed, with the logistic support requirements evolving after the design is established as being "fixed." On

[1] A system may vary in form, fit, and function. We may be discussing a worldwide communication network, a group of aircraft accomplishing a mission at a designated geographical location, or a small ship transporting cargo from one location to another. The system, oriented to a function, is discussed at various levels throughout this text. Also, refer to B.S. Blanchard, and W.J. Fabrycky, *Systems Engineering and Analysis*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981, for definition and classification of systems.

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numerous occasions, this practice has been costly—with the prime equipment lacking in design for supportability, and the various elements of logistic support not being compatible with the prime equipment or with each other. In addition, many of the necessary items of support have not been available on a timely basis; that is, items were delivered either too early or too late. In essence, improper attention to logistics has been predominant in the past, and the elements of the system have been fractionated and not well integrated in the development process.

With the advent of new technologies and the increasing complexities of systems today, combined with limited resources and reduced budgets, it is essential that all facets of a system be addressed on an integrated basis. If the results are to be effective, logistics must be considered on an integral basis with all other elements of the system. Logistic support must be initially planned and integrated into the overall system development process to assure an optimum balance between the prime equipment and its related support. This balance considers the performance characteristics of the system, the input resources required, the effectiveness of the system, and the ultimate life-cycle cost.

The area of logistics is experiencing rapid growth and has undergone considerable change in recent years. The objective of this chapter is to provide

the reader with a basic understanding of the need for logistics, the scope of logistics, logistics in the system life cycle, and some of the terms most commonly used in the language of logistics.

1.1. Scope of Logistics

Historically, the concept of logistics stems from specific facets of military and industrial management. In the military sense, Webster defines logistics as

> The procurement, maintenance, and transportation of military material, facilities, and personnel.[2]

Further, a United States Air Force technical report defines logistics as

> The science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, logistics pertains to those aspects of military operations which deal with (a) design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of materiel; (b) movement, evacuation, and hospitalization of personnel; (c) acquisition or construction, maintenance, operation, and disposition of facilities; and (d) acquisition or furnishing of services.[3]

In essence, logistics from a military view has primarily been oriented to "system/product support" and has included the elements of maintenance planning, test and support equipment, supply support, transportation and handling, facilities, personnel and training, and technical data.[4]

In the industrial or commercial sector, logistics, often called "business logistics" or "industrial logistics," has been defined to include such activities as material flow, product distribution, transportation, purchasing and inventory control, warehousing, customer service, and the like. More specifically, Magee has offered the following definition:

> The art of managing the flow of materials and products from source to user. The logistic system includes the total flow of materials, from the acquisition of raw materials to the delivery of finished products to the ultimate users. . . .[5]

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[2] *Webster's Seventh New Collegiate Dictionary*, G. & C. Merriam Company, Publishers, Springfield, Mass., 1963, P. 497.

[3] Gluck, F., ed., Technical Report No. 5, *A Compendum of Authenticated Logistics Terms and Definitions*, School of Systems and Logistics, U.S. Air Force Institute of Technology, WPAFB, Ohio, 1970.

[4] DOD Directive 4100.35, "Development of Integrated Logistics Support for Systems/Equipment," Department of Defense, Washington, D.C., October 1970.

[5] Magee, J. F., *Industrial Logistics*, McGraw-Hill Book Company, New York, 1968.

Bowersox offers a comparable definition:

> The process of managing all activities required to strategically move raw materials, parts and finished inventory from vendors, between enterprise facilities, and to customers.[6]

The activities associated with business (or industrial) logistics have in the past been primarily oriented to production operations and the physical distribution of goods and services by the producer. On the other hand, emphasis of the military or defense environment has been placed on the sustaining life-cycle support of the system or product while in use by the consumer. In both situations, logistics has been considered as a "downstream" effort, and the overall requirements for logistics have not been very well defined or integrated.

More recently, logistics has been viewed on a much broader scale and the field of logistics has been growing at a rapid pace, stimulated primarily by the technological, sociological, and economic trends in our world today. Systems and products have become more complex as technology advances, and logistics requirements have increased in general. Not only have the costs associated with system/product acquisition increased significantly in the past decade, but the costs of logistic support have also been increasing at an alarming rate. At the same time, the current economic dilemma of decreasing budgets combined with upward inflationary trends result in less money available for the acquisition of new systems and/or for the maintenance and support of those items already in use.

In view of these trends, one of the greatest challenges facing industry, businesses, government agencies, and the general consumer of products and services today is the growing need for more effective and efficient management of our resources. The requirement to increase overall productivity in a resource-constrained environment has placed emphasis on *all* aspects of the system/product life cycle, and logistics has assumed a major role comparable to research, design, production, and system performance during operational use. The need to address total system *life-cycle cost* (in lieu of acquisition cost only) is evident, and experience has shown that logistic support is a major contributor to life-cycle cost—at least on the basis of those costs which are visible! Further, experience has indicated that a great deal of the impact on the projected life-cycle cost for a given system or product stems from decisions made during the early phases of advance system planning and conceptual design. Decisions at this point have a major impact

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[6]Bowersox, D. J., *Logistics Management*, Macmillan Publishing Co., Inc., New York, 1974. Two additional references that cover the area of "business logistics" are (a) Ballou, R. H., *Business Logistics Management*, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1973, and (b) Heskett, J. L., Glaskowsky, N. A., and Ivie, R. M., *Business Logistics*, 2nd ed., The Ronald Press, Company, New York, 1973.