PRENTICE HALL
SPACE TECHNOLOGY SERIES

Thomas F. Walton

TECHNICAL DATA REQUIREMENTS FOR SYSTEMS ENGINEERING AND SUPPORT

PRENTICE-HALL INTERNATIONAL SERIES
IN SPACE TECHNOLOGY

TECHNICAL DATA REQUIREMENTS FOR SYSTEMS ENGINEERING AND SUPPORT

Thomas F. Walton

Manager Technical Data Department
TRW Space Technology Laboratories
Thompson Ramo Wooldridge Inc.

In Collaboration with
Clare Bull, Science Editor, Jet Propulsion Laboratory

Prentice-Hall, Inc., *Englewood Cliffs, N.J.*

Library of Congress Catalog Card Number 65-14084

Printed in the United States of America
89687C

TECHNICAL DATA REQUIREMENTS FOR SYSTEMS ENGINEERING AND SUPPORT

PRENTICE-HALL INTERNATIONAL SERIES
IN SPACE TECHNOLOGY

C. W. Besserer and Floyd E. Nixon, Editors
PRENTICE-HALL, INC.

PRENTICE-HALL INTERNATIONAL, UNITED KINGDOM AND EIRE
PRENTICE-HALL OF CANADA LTD., CANADA

ALEXANDER AND BAILEY *Systems Engineering Mathematics*
BAZOVSKY *Reliability Theory and Practice*
BELL *Cryogenic Engineering*
CORLISS AND HARVEY *Radioisotopic Power Generation*
DEUTSCH *Orbital Dynamics of Space Vehicles*
ELLIS AND LUDWIG *Systems Philosophy*
FOGEL *Biotechnology: Concepts and Applications*
GERATHEWOHL *Principles of Bioastronautics*
KOLK *Modern Flight Dynamics*
LINDEN *Printed Circuits in Space Technology*
LLOYD AND LIPOW *Reliability: Management, Methods, and Mathematics*
LOH *Dynamics and Thermodynamics of Planetary Entry*
MACKAY *Design of Space Powerplants*
MACOMBER AND FERNANDEZ *Inertial Guidance Engineering*
MCMAHON *Astrophysics and Space Science: An Integration of Science*
NELSON AND LOFT *Space Mechanics*
ORDWAY, GARDNER, AND SHARPE *Basic Astronautics*
ORDWAY, GARDNER, SHARPE AND WAKEFORD *Applied Astronautics*
PEDERSEN *Nuclear Energy in Space*
RING (ED.) *Rocket Propellant and Pressurization Systems*
SAMARAS *Applications of Ion Flow Dynamics*
SAMARAS *Theory of Ion Flow Dynamics*
SANDLER *Systems Reliability Engineering*
SCHLESINGER, *et al.* *Principles of Electronic Warfare*
SLAGER *Space Medicine*
STEARNS *Navigation and Guidance in Space*
STILITZ (ED.) *Aerospace Telemetry*
STOIKO AND FURTH *Rocket Powered Boosters*
WALTON *Technical Data Requirements for Systems Engineering and Support*
WILKINS *Theoretical Evaluation of Chemical Propellants*

PRENTICE-HALL INTERNATIONAL, INC., *London*
PRENTICE-HALL OF AUSTRALIA, PTY., LTD., *Sydney*
PRENTICE-HALL OF CANADA, LTD., *Toronto*
PRENTICE-HALL OF INDIA (PRIVATE) LTD., *New Delhi*
PRENTICE-HALL OF JAPAN, INC., *Tokyo*

PREFACE

The total communications necessary in conceiving, developing, and supporting modern systems, involve many kinds of technical data. As mysteries of nature and science become unraveled, better means of communicating new facts and theories are constantly sought. Progress in the development of a many-faceted system is very much dependent on how well the communication problems are resolved. This takes a strong data-oriented management and effective program control, particularly for large system programs that involve many activities in widespread locations.

Personnel in charge of data activities must have a broad knowledge of total system requirements, particularly in terms of the communications that will be needed. Also, ideally, these people should be supported by personnel who have the knowledge and capabilities necessary to generate effective technical data.

This book is concerned with the multitudinous forms of technical data that are needed in all phases of the systems engineering efforts, as well as the operational functions in system programs.

Systems engineering embraces the entire program needed to develop and support a complex system. It includes hardware, facilities, people, and data. Hence, the systems engineer's job is to see to it that each fractional part of a system is developed from a total view perspective. This view considers the broad system objectives, present and future potential developments in the state-of-the-art, economics, and basic resources. The endpoint objective, in broad terms, is to deliver a complete operational system that will meet requirements with the most reasonably advanced technology at a practical cost.

As referred to in this textbook, data are the communications needed

to direct and monitor the many human operations that must be performed before system objectives can be reached. They form the largest part of many system programs. They include the vast spectra of data that cover study reports, requirements analyses, specifications, engineering drawings and associated lists, reliability, maintainability, inspection and calibration requirements, equipment logs, technical information files, personnel requirements, training, training equipment planning, configuration control, facilities support, manufacturing, installation, assembly and checkout, procurement, test support, operations and maintenance, overhaul, and engineering changes. Many other data, both technical and administrative, are also needed to support the various research, development, activation, and operational phases of complex system programs.

Carefully planned generation, development, test, verification, and control of technical data can greatly enhance the progress of any system program. Conversely, unless the data are not only adequate, accurate, and reliable, but also timely, system development and activation can be seriously hampered. In the same vein, if the methods used in preparing the data result in unnecessary, duplicative, and other redundant type efforts, the data program can become a deficit instead of an asset. Top management concern in this area must be implicit for proper data program achievement. Skilled data specialists are needed both in management and in data development for proper accomplishment of program objectives.

This text describes a systems engineering approach for effectively correlating the total system data needed in complex system development programs. Under an integrated data concept, the approach should be aimed at developing effective technical data as an integral part of other efforts to develop hardware, facilities, and personnel subsystems. This is fundamental to an integrated system concept. Technical data are the common denominator for all technical matters since they are the communication link needed for efficient accomplishment. Data must be provided to support all phases of identification, development, use, and maintenance of the total system. Data also must provide historical records to serve as foundations for continuing improvements.

By looking at the full spectra of technical data requirements, from the viewpoint of total system requirements, minimum essential but adequate data should be supplied at minimum costs. By means of a system integrated approach, only essential elements of data are allowed to be developed, quality assurance and timely delivery are provided, proper usage is assured, and unnecessary efforts are avoided. By looking at the whole of system requirements, data reliability and cost effectiveness are also achieved.

Past events have proved that an informed management is a most critical factor to the successful accomplishment of cost effective data programs. Studious attention to all facets of the program, and the capability of instant

and proper reactions to all problems are paramount management qualifications. Standards, controls, and continuous monitoring are necessary to assure correct identification of requirements, development, production, quality assurance, and timeliness.

This book is concerned principally with the technical data that are needed for a typical military or space system. However, the principles and techniques are applicable to many commercial and industrial enterprises. All basic data requirements to meet primary technical objectives and the reasons for creating them are explained. Military programs (principally Air Force) and Space Systems are used as examples. Techniques that are most commonly applied to the establishment, development, and control of technical data requirements are also defined in applicable parts of the book.

Chapters 1 through 8 describe the major technical data requirements. Data described in Chapters 2 through 7 are covered in the same sequence that they are generally encountered under Government contracts. Chapter 8 covers many other ancillary data that are needed in support of system procurement, manufacturing, installation, assembly and checkout, test, and other program functions. Chapters 9 through 12 describe principles and requirements for management and administration, development and verification, production and quality assurance, cost controls, automation, and contracting. Chapter 13 summarizes the many ideas that have been presented, both old and new, and relates them all to the predominating principle in this book—the integrated data concept.

A glossary is provided to familiarize newcomers in this field with common terminologies used in the systems engineering and data programs. A Bibliography provides a list of other suggested reading and text references.

Grateful acknowledgements are due to many friends and associates of both large and small business enterprises, professional associations and societies, and various Government agencies, all of whom have contributed to the material and ideas presented in this book.

Much of the information has been made available through close associations with military and other Government agencies—in particular, the Ballistic Missile Division of the Air Force Systems Command. Requirements of data programs as they are recognized by most of the major contractors doing both commercial and Government business are reflected throughout the book. Special acknowledgment is given to TRW Space Technology Laboratories. Their role in performing systems engineering and technical direction on Ballistic Missile Programs has made possible the broad associations with Government agencies and industry that have been needed to acquire this information.

Great appreciation is extended to editor Clare Bull. Mr. Bull has contributed considerable material on technical report requirements, editing, and the other segments of text in addition to performing a literary and technical edit of the book. Special thanks are also extended to technical editors C. W. Besserer and Floyd E. Nixon for their very valuable assistance.

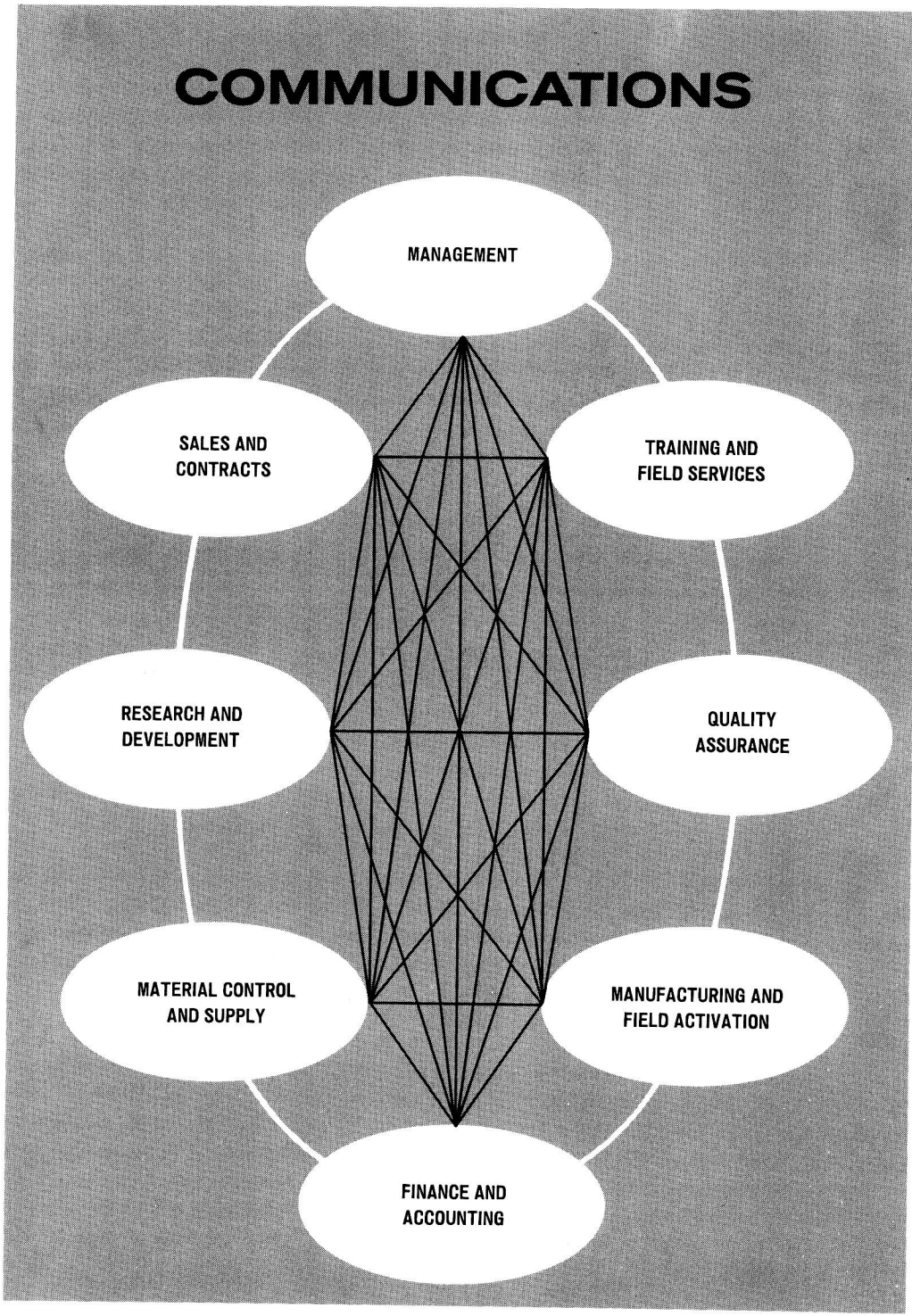
To list the many personnel in the various military departments and other Government agencies, as well as those in industry, who have contributed ideas and material reflected in this book would take many pages. However, in part, special acknowledgment is extended to the military works that the author has had contact with as contributed by Generals Frank S. Besson, Mark E. Bradley, and Bernard A. Shriever, Vice Admiral W. A. Schoech, Lieutenant General Austin Davis, Major General Samuel C. Phillips, Colonels Benjamin N. Bellis, John S. Chandler, Norman L. Murray, L. A. Robbins, and William F. Stevens, Lieutenant Colonels David A. Cook, Frank A. Heasley, William O. Rennhack, William C. Shepherd, and Dr. Edwin G. Triner, Major E. W. Milauckas, Captain R. J. Latina, Stanley A. Termaine, and in the Department of Defense, Walter M. Carlson, William S. Hutchinson, William T. Mason, and Major General Allen T. Stanwix-Hay. Those of industry who have contributed to the book's development, directly and indirectly, are Arnold R. Anchordoguy, Neil R. Anderson, Allen E. Brett, Dr. J. R. Burnett, John K. Burnett, Dr. Wilton P. Chase, Thomas G. Craddock, Dr. Richard D. DeLauer, Donald S. Elliott, Richard T. Golightly, Druce Henderson, Robert B. Hess, Ivar M. Holliday, Dr. Joseph E. Judge, Stephen C. Kapernaros, Duane J. Laffey, Joseph Marcella, Charles S. McCormick, Dr. Ruben F. Mettler, Orion Myrup, John Sabatino, Virginia Steger, Gerald L. Stout, Norman Stump, John Ward, Edmund A. Waters, Sidney Wilcox, and Doris Walton, wife of the author.

Credits for data contributions are given in footnotes throughout the book.

THOMAS F. WALTON

TECHNICAL DATA REQUIREMENTS FOR SYSTEMS ENGINEERING AND SUPPORT

CONTENTS


COMMUNICATIONS
MANAGEMENT
SALES AND CONTRACTS
TRAINING AND FIELD SERVICES
RESEARCH AND DEVELOPMENT
QUALITY ASSURANCE
MATERIAL CONTROL AND SUPPLY
MANUFACTURING AND FIELD ACTIVATION
FINANCE AND ACCOUNTING

1

SYSTEM PROGRAM RELATIONSHIPS

The tremendous efforts devoted to scientific research in the past decade have produced paradoxical by-products. The outpouring of new ideas for new machines has created bottlenecks in the development of systems. Each new technical breakthrough produces simpler or more effective ways of accomplishing old objectives. Heretofore, turning new ideas into hardware, and developing the hardware into an operational system, have required so much time that many system parts became obsolete before operational phases were reached. Efforts to introduce new inventions and concepts into the system delayed schedules and kept operational systems out of commission while modifications were made. In some cases these delays have been even more serious, to the degree that entire systems had to be scrapped before becoming operational due to improvements in competitive systems. The basic source problem of delays due to new ideas entering a development program has been a lack in effective communications. The complex data flow needed for effective communications in system programs is illustrated in the frontispiece. A measure of relief is provided by means of the "integrated system concept." This reduces the overall time normally required between the conceptual design and the field operation. It also assures adequate consideration of every detail requirement, including that of communication itself.