SYSTEMS ENGINEERING PRINCIPLES AND PRACTICE

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Contents

Illustrations

Tables

Preface

Learning how to be a successful systems engineer is entirely different from learning how to excel at a traditional engineering discipline. It requires developing the ability to think in a special way,—to acquire the "systems engineering viewpoint," and to make the central objective the system as a whole and the success of its mission. The systems engineer faces in three directions—the system user's needs and concerns, the project manager's financial and schedule constraints, and the capabilities and ambitions of the engineering specialists who have to develop and build the elements of the system. This requires learning enough of the language and basic principles of each of the three constituencies to understand their requirements and negotiate balanced solutions acceptable to all. The role of interdisciplinary leadership is the key contribution and principal challenge of systems engineering, and it is absolutely indispensable to the successful development of modern complex systems.

1.1 OBJECTIVES

"Systems Engineering Principles and Practice" is a textbook designed to help students learn to think like systems engineers. Students seeking to learn systems engineering after mastering a traditional engineering discipline often find the subject highly abstract and ambiguous. To help make systems engineering more tangible and easier to grasp, the book provides several models: 1) a hierarchical model of complex systems, showing them to be composed of a set of commonly occurring building blocks or components, 2) a system life

cycle model derived from existing models, but more explicitly related to evolving engineering activities and participants, 3) a model of the steps in the systems engineering method, and their iterative application to each phase of the life cycle, 4) a concept of "materialization" that represents the stepwise evolution of an abstract concept to an engineered, integrated and validated system, and 5) repeated references to the specific responsibilities of systems engineers as they evolve during the system life cycle, and to the scope of what a systems engineer must know to perform these effectively. The book's significantly different approach is intended to complement the several excellent existing textbooks that concentrate on the quantitative and analytical aspects of systems engineering.

Particular attention is devoted to systems engineers as professionals—their responsibilities as part of a major system development project, the knowledge, skills and mind-set they must acquire to be successful. The book stresses that they must be innovative and resourceful, as well as systematic and disciplined. It describes the special functions and responsibilities of systems engineers in comparison to those of system analysts, design specialists, test engineers, project managers and other members of the system development team. While the book describes the necessary processes that systems engineers must know and execute, it stresses the leadership, problem-solving and innovative skills necessary for success.

The function of systems engineering as defined here is to "guide the engineering of complex systems". To learn how to be a good guide requires years of practice, and the help and advice of a more experienced guide, who knows "the way". The purpose of this book is to provide a significant measure of such help and advice through the organized collective experience of the authors and other contributors.

This book is intended for graduate engineers or scientists who aspire to or are already engaged in careers in systems engineering, project management or engineering management. Its main audience is expected to be engineers educated in a single discipline, either hardware or software, who wish to broaden their knowledge so as to deal with system problems. It is written with a minimum of mathematics and specialized jargon so that it should also be useful to managers of technical projects or organizations, as well as to senior undergraduates.

1.2 ORIGIN AND CONTENTS

The main portion of the book has been used for the past five years to support the five core courses of the Johns Hopkins University Master of Science program in Systems Engineering, and is thoroughly class-tested. It has also been used successfully as a text for distance course offerings. In addition, the book is well suited to support short courses and in-house training.

The book consists of 14 chapters grouped into five parts:

Part I. The Foundations of Systems Engineering, consisting of Chapters 1 through 4, describes the origin and structure of modern systems, the stepwise development process of complex systems, and the organization of system development projects.

Part II. Concept Development, consisting of Chapters 5 through 7, describes the first stage of the system life cycle in which a need for a new system is demonstrated, its requirements are developed and a specific preferred implementation concept is selected.

Part III. Engineering Development, consisting of Chapters 8 through 10, describes the second stage of the system life cycle, in which the system building blocks are engineered and the total system is integrated and evaluated in an operational environment.

Part IV. Post-Development, consisting of Chapters 11 and 12, describes the role of systems engineering in the Production, Operation, and Support phases of the system life cycle, and what domain knowledge of these phases in the system life cycle a systems engineer should acquire.

Part V. Special Topics consists of Chapters 13 and 14. Chapter 13 describes the pervasive role of software throughout system development, and Chapter 14 addresses the application of modeling, simulation, and trade-off analysis as systems engineering decision tools.

Each chapter also contains a summary, homework problems, and a bibliography. A Glossary of important terms is also included. The chapter summaries are formatted to facilitate their use in lecture viewgraphs.

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