HOW TO DO SYSTEMS ANALYSIS

JOHN E. GIBSON
WILLIAM T. SCHERER
School of Engineering and Applied Science
Department of Systems and Information Engineering
University of Virginia

WILLIAM F. GIBSON

Wiley-Interscience
A JOHN WILEY & SONS, INC., PUBLICATION

HOW TO DO SYSTEMS ANALYSIS

BICENTENNIAL
1807
WILEY
2007
BICENTENNIAL

THE WILEY BICENTENNIAL–KNOWLEDGE FOR GENERATIONS

Each generation has its unique needs and aspirations. When Charles Wiley first opened his small printing shop in lower Manhattan in 1807, it was a generation of boundless potential searching for an identity. And we were there, helping to define a new American literary tradition. Over half a century later, in the midst of the Second Industrial Revolution, it was a generation focused on building the future. Once again, we were there, supplying the critical scientific, technical, and engineering knowledge that helped frame the world. Throughout the 20th Century, and into the new millennium, nations began to reach out beyond their own borders and a new international community was born. Wiley was there, expanding its operations around the world to enable a global exchange of ideas, opinions, and know-how.

For 200 years, Wiley has been an integral part of each generation's journey, enabling the flow of information and understanding necessary to meet their needs and fulfill their aspirations. Today, bold new technologies are changing the way we live and learn. Wiley will be there, providing you the must-have knowledge you need to imagine new worlds, new possibilities, and new opportunities.

Generations come and go, but you can always count on Wiley to provide you the knowledge you need, when and where you need it!

William J. Pesce

WILLIAM J. PESCE
PRESIDENT AND CHIEF EXECUTIVE OFFICER

Peter Booth Wiley

PETER BOOTH WILEY
CHAIRMAN OF THE BOARD

HOW TO DO SYSTEMS ANALYSIS

JOHN E. GIBSON
WILLIAM T. SCHERER
School of Engineering and Applied Science
Department of Systems and Information Engineering
University of Virginia

WILLIAM F. GIBSON

Wiley-Interscience
A JOHN WILEY & SONS, INC., PUBLICATION

Copyright © 2007 by John Wiley & Sons, Inc. All rights reserved.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750–4470, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748–6011, fax (201) 748–6008, or online at http://www.wiley.com/go/permissions.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762–2974, outside the United States at (317) 572–3993 or fax (317) 572–4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic formats. For more information about Wiley products, visit our web site at www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

Gibson, John E.
How to do systems analysis / by John E. Gibson, William T. Scherer, and William F. Gibson.
p. cm.
Includes index.
ISBN 978-0-470-00765-5 (cloth)
1. System analysis. I. Scherer, William T. II. Title.
T57.6.G543 2007
658.4′032 – dc22

2006033568

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

Contents

Preface

There is significant front matter in this book, but as I hope we make it clear in the text, the contextual integrity is critical! Following this introduction are a personal note from me, a note from Jack's son, Will Gibson, a perspective of a former student of Jack and me, Scott Ferber, and, finally, Jack's original preface.

The unique approach in this book is to motivate systems thinking, or as we like to say: "See the world with new eyes—that of a systems thinker." Throughout the book are examples, from the past and from today's pressing issues, which illustrate these concepts, along with case studies to give the reader exposure to the practice of systems analysis and systems engineering. The resulting book is appropriate for numerous fields and professionals that need input from systems engineering, including anyone working in the analysis of complex systems, such as in business consulting, health care, telecommunications, and so on.

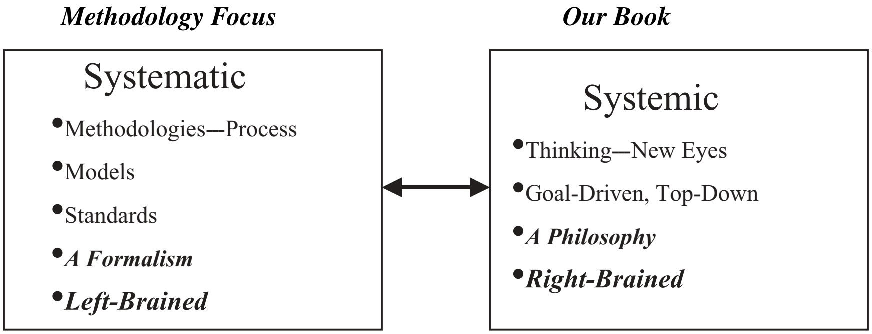
I believe that the present books in the area of Systems Analysis and Systems Engineering are excellent; however, many fail to emphasize the art of systems problem solving (systems analysis) by focusing instead on operations research methods (mathematical models such as linear programming) or on the formal Systems Engineering processes (as stressed by INCOSE: The International Council on Systems Engineering). This book focuses on systems analysis, broadly defined also to include problem formulation and interpretation of proposed alternatives in terms of the value systems of stakeholders. Therefore, this book is a *complement*, not a substitute, to the other "traditional" books when teaching systems engineering and systems analysis. However, the nature of problem-solving discussed in this book is appropriate to a wide range of systems analyses. Thus the book can be used as a stand-alone book for teaching the analysis of systems.

Numerous other books describe the processes of systems engineering, including systems engineering handbooks developed by NASA, DOD, Boeing, and so on.

Currently, there is also considerable discussion on the concept of system-of-systems (S.O.S.)—that is, systems that are of significant complexity and order that they require methodologies beyond the classic systems methodologies that are all basically derivatives of MIL-499B, a classic systems engineering military standard. The emphasis of this book, however, is not on the formal process of systems engineering eloquently described in the footnoted books, but on the systems analysis component and the associated thought processes.

The design of this book is such that it can be used at different educational levels. Undergraduates, for example, focus on the basic problem-solving ideas, and the expected depth in their analyses and cases would be significantly less than expected from graduate students. How the book is used—that is, as a primary text or supplemental/complementary text—also depends on the student level. My experiences in using the draft at both levels has shown that experienced students (such as our Accelerated Master's Degrees students—working professionals in an executive format degree program) clearly understand (from their experiences) the issues addressed in the book and can relate the material directly to their work experiences, especially from what I call the systemic perspective; thus, for them the book is a required and a primary source. Undergraduates, typically without the benefit of significant work experience, see the value in a general problem-solving method that applies to many situations, with more focus on the systematic aspects of the material. For them we use the book as supplemental.

Fundamentally, I see two worlds typical in systems engineering (both are necessary!):



By systemic, we mean affecting the entire system or holistic.[*] By systematic, we mean a formal step-by-step process (in the most direct form, computer code is an

---

[*] A wide-reaching term, designating views in which the individual elements of a system are determined by their relations to all other elements of that system. Being highly relational, holistic theories do not see the sum of the parts as adding up to the whole. In addition to the individual parts of a system, there are "emergent," or "arising," properties that add to or transform the individual parts. As such, holistic theories claim that no element of a system can exist apart from the system in which it is a part. Holistic theories can be found in philosophical, religious, social, or scientific doctrines. [*source*: Public Broadcasting Systems.]

example). This book makes a unique contribution by addressing the right-hand side, the systemic side. An analogy could be made to the left-brain (logical; often engineers) and right-brain (artistic) thinkers. The book focuses on problem definition, which is in my opinion a very difficult part of the systems process and an often neglected (or failed) part in practice (and books).

So, we have *How to Do Systems Analysis*. This book is not intended to be an instructional guide to systems engineering (such as practiced in industry or government), but a book that engages one in beginning or enhancing their journey toward becoming a systems thinker—a requisite skill for systems engineers and all problem solvers. *Trends come and go, but quality Systems Analysis thinking abides*. Throughout the book are pointers and references to excellent books and articles that provide detailed techniques, research, and think pieces on the disparate aspects of systems analysis. I have deliberately left much of Jack's original material alone. I feel strongly that there is considerable wisdom in these words and that this wisdom is timeless. Unfortunately, systems thinking and good systems engineering remain elusive, as evidenced by the recent (summer 2006) experiences with the Big Dig in Boston. Many of Jack's examples and experiences, some dating to the 1950s, add considerable insight into the realm of systems thinking. I have been using draft parts of this book since taking over Jack's graduate course, *Introduction to Systems Engineering*, in 1992. The material has uniformly received excellent reviews from students for its unique perspective on problem solving in all types of domains. It is particularly relevant for students with some professional experience who appreciate its practical and accessible concepts.

How would I read this book? Top-down of course. I would start with reading Chapter 10 completely, followed by Chapter 1, then reading the first several pages of Chapters 2–9. Next would be Chapters 2–4. Finally, the remaining portions of Chapters 5–9. For undergraduate students, Chapters 2–4 form the core concepts of a general systems analysis methodology. Chapter 10 is in effect an executive summary of systems analysis and can basically stand on its own.

I encourage you engage in and enjoy the material.

WILLIAM T. SCHERER

Charlottesville, Virginia
March 2007

A Personal Note from William T. Scherer

He stormed into the room, a large man with a commanding presence with a shock of white hair—the Dean of The School of Engineering and Applied Science at The University of Virginia. Twenty or so of us—all undergraduate transfer students—sat-up at attention and dare not speak while the Dean greeted us, told us we were joining a select group of students, and then gave us a strong challenge and charge to be the best. That was my first meeting with Jack in 1978 as a third-year (junior) transfer student to the new Department of Systems Engineering at UVa. My second meeting did not go as well. Ten of us (rising fourth years) had been selected to a summer research program and were called by the Dean to attend an early morning meeting during the summer program. Unfortunately, being undergraduates and students, the morning hours were not our best or favorite. None of the 10 students made it to the meeting with the Dean. Following an informative letter, a second meeting was arranged and the attendance was perfect. Our lecture from the Dean on being a professional, an adult, responsible, and so on, was, to say the least, not in the current collaborative style of lecturing that many of us employ. My third interaction was not even as good as the second. During my graduate studies I started a course with Jack on *Management for Engineers*, and in the second class I challenged Jack on the lack of exact specifications in the homework assignment and the rampant ambiguity. I was informed, in a fairly rigorous Type A manner, about my being a typical bottom-up engineer who was incapable of handling the inherent ambiguity in any real-world, open-ended problem, a skill required in systems engineering. After a brief but spirited conversation, I was invited to leave the class. That was 1981 and I had begun my systems training through some hard lessons. By the late 1980s I was a colleague of Jack's in the Systems Department, and, more importantly, I had finally figured it out and was beginning to think like a systems engineer. For the last several years of Jack's life I was able to share numerous conversations with him and also work on several projects with his consulting business.

Through these interactions I began the continuing, but never-ending, journey toward being a systemic thinker. Most enjoyable, since my office was next to his, was when he would storm in with a new idea or a frustration over some mind-numbing, anti-systems activity going on at the University or elsewhere. My varied interactions with Jack contributed significantly to my growth as a "systems" professional.

WILLIAM T. SCHERER

Charlottesville, Virginia
March 2007

A Personal Note from William F. Gibson

At the time of his death in August 1991, my father was completing *How to Do Systems Analysis*. He was looking forward to using this text in his undergraduate- and graduate-level classes in the Systems Engineering Department at the University of Virginia. He was doing what he enjoyed most—-imparting his insight and knowledge to a group of inquisitive minds.

Jack Gibson spent his life as a student and an educator. He was a student of life; for an engineer, he was unparalleled in his voracious quest for information about those disciplines not normally associated with "hard sciences." He was an educator; he chose a career that was not as rewarding in a monetary sense (although he provided well for his family). No, my dad's rewards were paid in the responsiveness that he saw in the eyes of his students, fellow academicians, and clients, to new ideas. Jack constantly challenged people to do better, to think more deeply, and to articulate more clearly.

How to Do Systems Analysis is the last of Jack's "nontraditional" engineering education texts. He recognized that the end product of a university classroom is to educate students in the engineering disciplines so that they could get a job upon graduation. He wanted their course material to be relevant; he wanted examples to be topical. Those students learned that the business world is nonlinear, has no "correct answers," and is filled with managers who make tremendous demands with deadlines that are impossible to meet. This book is designed to reinforce that perspective.

I enjoyed editing the last 10 of my father's books. I used to spend my spare time in college and graduate school correcting syntax and grammar. When I finally started working, I began to understand the concepts that Jack tried to communicate to students; I was able to provide salient examples that Jack used in his books. This text is more special, however. This is the last one. Perhaps I delayed in completing this one because it was the last opportunity that Jack was able to use to speak to me.

I hope that you can share in his insights, learn from his experiences, and apply the lessons to your own benefit.

I need to thank a number of people who either assisted in the production of this text or kept driving me to complete it. First are Jack's colleagues and students. Among the former are Drs. Julia Pet-Edwards and Manuel Rossetti and Maj. Richard Metro, for their continuing interest and desire in the subject matter and requests to use the textbook at their universities. Especially among the latter is Jennifer Tyler, who was my dad's last graduate assistant. Jennifer helped tremendously, in 1992 and 1993, in my revisions to the text.

Finally, are my wife, Hilary Wechsler Gibson, and my Dad. They never had the chance to meet; I know that they would have enjoyed each other immensely. Hilary kept pushing me to my desk, so I would complete this work. To my Dad, all I can say is "Thank you." As with all his previous books, I know that my Dad would dedicate the book to his wife, my mom. So, this book is dedicated . . . To Nancy.

WILLIAM F. GIBSON

New York, New York
March 2007

A Personal Note from Scott F. Ferber

How to Do Systems Analysis* = *How to Solve Problems. I attended the University of Virginia to study Systems Engineering under Jack Gibson and Bill Scherer so that I could learn how to solve problems, any type of problem. Their program was unique in that it focused on problem-solving for all disciplines rather than one discipline.

This book epitomizes the philosophy that attracted me to their department. Whenever confronted with a challenge, I apply the exact approach as outlined in this book. *How to Do Systems Analysis* has guided me through countless academic, business, and personal opportunities since I took Jack's class based on this book in 1990. For example, I am applying the Systems methodology today on a multitude of issues, ranging from career moves to planning my 4-year-old son's birthday party.

To learn how to solve problems is to learn how to do systems analysis. Everyone can benefit from improved problem-solving; hence, this book is for people from all disciplines and all walks of life. Thank you Jack, Will, and Bill for bringing to fruition the greatest insights I have ever learned. I promise not to forget what you taught me, to always use it, and to use it for good.

SCOTT F. FERBER

Original Preface from Jack Gibson

There appear to be three generic points of view one may take in writing a textbook. These are . . . the *problem-centered* viewpoint, the *technique-centered* viewpoint, and the *reader-centered* viewpoint. Of course, it is also possible to write a book with no consistent point of view at all, one probably need not add. The problem-centered view is not common in general texts but is an acceptable approach for advanced texts on focused, narrow topics. My text *Designing the New City*, Wiley, 1977, was written from this perspective. However, if the author has an introductory, general purpose in mind, this approach leads to difficulties. In such a situation, problem-centering usually leads to a book of recipes. That is, the author is led to saying for a series of instances, “given this problem, here is how to handle it.” One becomes bogged down in specifics, and it is difficult to achieve a general perspective of the topic. This is a severe limitation in itself, and, furthermore, it is unappealing to the academic mind.

The technique-centered approach is more common in basic introductory texts. Generally speaking, technique-centered texts typically provide a chapter or two of introduction and then launch into a survey of the main topics and techniques in the field. It is assumed that the reader will be able to select the appropriate tools to solve his or her specific problem. If one is faced with a problem similar to the type of problems used to illustrate the technique under discussion in the text, this is a good approach. But what it gains in general perspective and an overall viewpoint, it may lose in usefulness in applicability. The technique-centered approach seems to be popular with academics, since we generally have a mind bent that seeks general understanding and we are less interested in problem-solving and specifics. I have written several texts with this perspective, among them being *Introduction to Engineering Design*, Holt, Rinehart & Winston, 1968, and *Nonlinear Automatic Control*, McGraw-Hill, 1963.

The reader-centered point of view has initial appeal as a guide to the perplexed, but in practice it sometimes descends to pontification and anecdotal generalities—that is, retailing of old and possibly irrelevant personal "war stories." This approach assumes a common starting point for its readers, and, as in the present text, this starting point is usually an assumption of a reader's unfamiliarity with the topic. *Scientific American* magazine practices this approach in a masterly way. The first paragraph or two of each of its articles is couched at a simple, obvious level and then acceleration is smooth and gradual.

For better or worse, the reader-centered approach is the one taken in this text. I will assume you are a systems analyst faced with a problem situation. We will go through a step-by-step approach to the application of the systems approach to the situation, using techniques as the need arises. We will not focus on the details of the analytic techniques to be used; it is assumed that you will learn the details of these (mostly mathematical) techniques elsewhere. From the present text, I hope you will learn just what "systems analysis" (SA) is and what the "systems approach" means. You will see from examining the cases, which are based on actual practice, how the need for mathematical techniques develops and how to apply them. Moreover, I hope that you will develop a sense of the pitfalls and difficulties in practicing SA. This is a tall order, especially for readers without professional work experience.

Unless you are able to provide a "reality check" from your own work experience, you may be tempted to accept the suggestions herein for analyzing problems as simple and obvious. In reality they are neither, but unlike advanced mathematics, which is obviously difficult going in, SA appears almost trivial on first observation. We will discuss this trap as we go on.

JACK GIBSON

Ivy, Virginia
January 1991

Acknowledgments

Many people have contributed to this book, but first and foremost is John Egan Gibson, one of the most intelligent and insightful people I have met and a true systems thinker. Many graduate students and faculty have provided insights and wisdom for the book. Drew Talarico provided considerable assistance in editing, fact checking, formatting, and proofreading. Finally, I'd like to acknowledge the considerable support and love from my wife, Amy, and my "Goddess Trio" of daughters: Kendall, Merritt, and Linden.

W.T.S.

This book is the culmination of the work of many individuals. The primary is John Egan Gibson. Over the years, I continue to be pleasantly surprised by the comments I receive from his students, colleagues, clients, and friends. His seminal ideas and insights continue to provide the framework by which individuals and groups analyze problems. Many of Jack's former graduate students, and faculty members provided valuable comments and perspectives on this work. Additionally, during my many hours at my computer and on the phone, when I was editing and managing the process of getting this text into print, I could not have completed my work without the help of two very important people. This book would not be in your hands without the love and support of my wife, Hilary Wechsler Gibson, and our son Teddy.

W.F.G.

Chapter 1

Introduction

sys·tem (sĭs′təm) *n.*

1. A group of interacting, interrelated, or interdependent elements forming a complex whole.
2. A functionally related group of elements, especially:
   a. The human body regarded as a functional physiological unit.
   b. An organism as a whole, especially with regard to its vital processes or functions.
   c. A group of physiologically or anatomically complementary organs or parts: *the nervous system; the skeletal system.*
   d. A group of interacting mechanical or electrical components.
   e. A network of structures and channels, as for communication, travel, or distribution.
   f. A network of related computer software, hardware, and data transmission devices.
3. An organized set of interrelated ideas or principles.
4. A social, economic, or political organizational form.
5. A naturally occurring group of objects or phenomena: *the solar system.*
6. A set of objects or phenomena grouped together for classification or analysis.
7. A condition of harmonious, orderly interaction.

How to Do Systems Analysis. By John E. Gibson, William T. Scherer, and William F. Gibson

8. An organized and coordinated method; a procedure.
9. The prevailing social order; the establishment. Used with: *You can't beat the system.*

[Late Latin systēma, systēmat-, from Greek sustēma, from sunistanai, to combine : sun-, syn- + histanai, set up, establish.]
Source: Answers.com: American Heritage

> In the systems approach, concentration is on the analysis and design of the whole, as distinct from ... the components or parts ... The systems approach relates the technology to the need, the social to the technological aspects; it starts by insisting on a clear understanding of exactly what the problem is and the goal that should dominate the solution and lead to the criteria for evaluating alternative avenues ... The systems approach is the application of logic and common sense on a sophisticated technological basis ... It provides for simulation and modeling so as to make possible predicting the performance before the entire system is brought into being. And it makes feasible the selection of the best approach from the many alternatives.
>
> Simon Ramo, *Cure for Chaos*, pp. 11, 12

1.1 WHAT IS A SYSTEM?

A system is a set of elements so interconnected as to aid in driving toward a defined goal. There are three operative parts to this short definition. First is the existence of a set of elements—that is, a group of objects with some characteristics in common. All the passengers who have flown in a Boeing 777 or all the books written on systems engineering form a set, but mere membership in a definable set is not sufficient to form a system according to our definition. Second, the objects must be interconnected or influence one another. The members of a football team then would qualify as a system because each individual's performance influences the other members.

Finally, the interconnected elements must have been formed to achieve some defined goal or objective. A random collection of people or things, even if they are in close proximity and thus influence each other in some sense, would not for this reason form a meaningful system. A football team meets this third condition of purposefulness, because it seeks a common goal. While these three components of our working definition fit within American Heritage's definitions, we should note that we are restricting our attention to "goal-directed" or purposeful systems, and thus our use of the term is narrower than a layman's intuition might indicate.[1]

It must be possible to estimate how well a system is doing in its drive toward the goal, or how closely one design option or another approaches the ideal—that is, more or less closely achieves the goal. We call this measure of progress or achievement the *Index of Performance (IP) (*alternatively, *Measures of Effectiveness [MOE], Performance Measures [PM], etc.).* Proper choice of an Index of Performance is crucial in successful system design. A measurable and meaningful measure of performance is simple enough in concept, although one sometimes has difficulty in conveying its importance to a client. It may be complex in practice, however, to establish an index that is both measurable and meaningful. The temptation is to count what can be counted if what really matters seems indefinable. Much justifiable criticism has been directed at system analysts in this regard. (Hoos, 1972). The Index of Performance concept is discussed in detail in Section 2.3.

Our definition of a system permits components, or the entire system in fact, to be of living form. The complexity of biological systems and social systems is such that complete mathematical descriptions are difficult, or impossible, with our present state of knowledge. We must content ourselves in such a situation with statistical or qualitative descriptions of the influence of elements one on another, rather than complete analytic and explicit functional relationships. This presents obvious objective obstacles, as well as more subtle subjective difficulties. It requires maturity by the system team members to work across disciplinary boundaries toward a common goal when their disciplinary methodologies are different not only in detail but in kind.

From these efforts at definition, we are forced to conclude that the words "system," "subsystem," and "parameter" do not have an objective meaning, independent of context. The electric utility of a region, for example, could be a system, or a subsystem, or could establish the value of a parameter depending on the observer's point of view of the situation. An engineer for the Detroit Edison Company could think of his electric utility as a system. Yet, he would readily admit that it is a subsystem in the Michigan Electric Coordinated System (MECS), which in turn is connected to the power pool covering the northeastern portion of the United States and eastern Canada. On the other hand, the city planner can ignore the system aspect of Detroit Edison and think of it merely supplying energy at a certain dollar cost. This is so if it is reasonable for him to assume that electricity can be provided in any reasonable amount to any point within the region. In this sense, the cost of electricity is a regional parameter. The massive Northeast U.S. power failure in 2003, along with the resulting repercussions directly affecting over 50 million people, clearly illustrates the regional nature of these systems.

That the function of an object and its relationship to neighboring objects depends on the observer's viewpoint must not be considered unusual. Koestler, for example, argues persuasively that this is true for all organisms as well as social organizations. For these units, which we have called "systems," he coins the term "holon."

> *But* "wholes" *and* "parts" *in this absolute sense just do not exist anywhere, either in the domain of living organisms or of social organizations. What we find are intermediate structures or a series of levels in an ascending order of complexity: sub-wholes which display, according to the way you look at them, some of the characteristics commonly attributed to wholes and some of the characteristics commonly attributed to parts.... The members of a hierarchy, like the Roman god Janus, all have two faces looking in opposite directions: the face turned toward the subordinate levels is that of a self-contained whole; the face turned upward toward the apex, that of a dependent part. One is the face of the master, the other the face of the servant. This* "Janus effect" *is a fundamental characteristic of sub-wholes in all types of hierarchies.* [Koestler, 1971]

1.2 TERMINOLOGY CONFUSION

Because one is often introduced to system analysis in a specific context, it may be confusing subsequently to find the method used in an entirely different context. Engineering students, for example, may follow a "systems" curriculum that specializes in automatic control, communications theory, computer science, information retrieval, and so on, and which entirely excludes general system planning and policy-oriented questions. (Brown and Scherer, 2000). Students of management may think of fiscal control or ERP (Enterprise Resource Planning) "systems" when they use the phrase "system analysis." We have sewage systems, social systems, and horse players' systems. Perhaps Koestler was wise to avoid the word "system" entirely, but then again, he only renamed the problem. Here is an example of a dual use of the word "system" that resulted in initial confusion by members of a government advisory panel.

A panel of engineers was requested by the federal government to establish the future research and development needs in the field of high-speed ground transportation (HSGT) (U. S. Department of Commerce, 1967; Herbert, 1968). The panel originally conceived the study in the categories shown in Figure 1.1. It soon became apparent, however, to the "system" subpanel that a number of the tasks, which they had been asked to consider, fell into the category we will call "general system planning." Such items as subsystem interaction, reliability, and system management are included in this category. Yet what about communications and control, the question of a single, overall centralized control computer system versus many individual machines, or the reporting of the position and velocity of individual vehicles? Just as surely, these are more specific "systems." Thus, the final report of the HSGT panel was organized as shown in Figure 1.2. This is a more functional arrangement, and it helped the panel to produce a less confusing and thus more useful report.

Thus far we have discussed the difference between the general or "comprehensive" system viewpoint we take in this text, i.e., the specific problem at issue, plus all of the

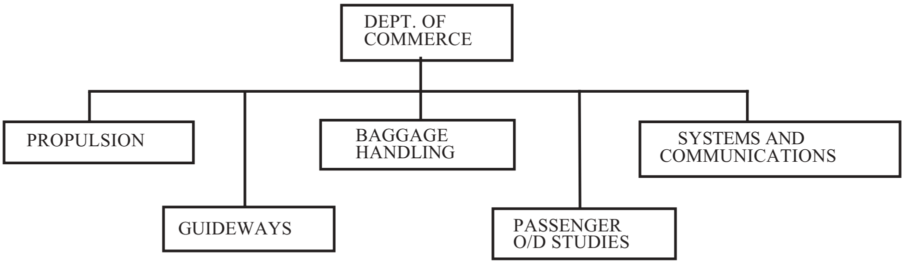


FIGURE 1.1 The original HSGT study concept. The Department of Commerce wished to assemble a study team to establish the concept of high-speed ground transportation (HSGT) on a conceptually correct basis. Originally, it felt that the study should have the five units shown above. However, when the team of experts assembled, they discovered that there existed considerable confusion as to the meaning of the "systems and communications" unit.