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The Analyst's Bookshelf

Hugh J. Miser, Editor

BOOKS

Reviews

FRANK A. HAIGHT, *Mathematical Theories of Traffic Flow*, Academic Press, Inc., New York, N. Y., 1963, 254 pages, \$9.00

THIS first text on road traffic theory is a welcome sign that at last the subject has become fashionable enough to support the scholarly structure essential to systematic progress in research. HAIGHT offers a coherent treatment of some aspects of traffic theory and a magnificently comprehensive bibliography. Thus, the book may be most useful for review and for reducing the considerable danger of duplicating extant work. Unfortunately, some defects, discussed below, limit its utility as a textbook.

There are seven chapters. The first, a review of elementary probability theory, seems to be useful and quite readable, although no mention is made of the statistical tools, such as sampling and discriminant analysis, required to relate theory to the real world. The second chapter is devoted to a modern treatment of single-channel queuing theory. Here, the mathematical sophistication is at about the same level as in SAATY's *Elements of Queuing Theory*, which latter may be preferred because its greater detail makes tutor-less study more practical. References to multiple channels, to various disciplines, and to bulk service are made, but—perhaps wisely—no further results are exhibited at this stage.

The main text begins with Chapter 3, "Fundamental Characteristics of Road Traffic." The relation between flow and concentration is discussed, with several theoretical formulations examined on the basis of whether they meet suitable boundary conditions. Very brief mention is given to car following and to the fluid-flow analogy. For example, the pioneering work by HERMAN and others on stability in car following is mentioned only once for the purpose of keying in the pertinent references.

Chapter 4, "Arrangements of Cars on a Road," reviews some techniques for devising and analyzing appropriate counting distributions. The detailed presentation includes compound gap distributions wherein two or more vehicle classes are intermixed. This chapter serves as introduction to the next one, "The Simple Delay Problem," which develops theoretical models for pedestrians crossing roads, for side-road queuing at main roads, and—as a particular case of the latter—for delays caused by fixed-interval traffic signals.

Chapter 6, "Miscellaneous Problems," includes stochastic theories for turning, merging, multilane traffic, and the effects of sequenced traffic signals. Parking is treated as analogous to telephone traffic, while bottlenecks are viewed as interactions between two interfering queues. The book's only reference to nonequi-

librium behavior is embodied here as a brief note on queuing through a rush hour.

The last chapter, "A Two-Lane Road," discusses how to formulate the equilibrium speed distribution as controlled by clustering and passing among vehicles with varying free speeds.

Thorough lists of references to each chapter and a supplementary one for the book as a whole are the most inclusive yet assembled for the topics covered. Misprints, troublesome diagrams, and unusual usages for symbols and definitions occur with enough frequency to be piquant, but their distractive effects seem only typical for a book of this type.

The presentation throughout is completely abstract; there appears to be such a conscientious effort to avoid experimental comparisons that the title might better have been *Mathematical Theories for (not of) Traffic Flow*. Even in this sense, the title is too general: while equilibrium queuing problems are presented with great thoroughness and on a quite sophisticated level, many other topics are ignored. There is almost nothing on networks, on instabilities and saturation phenomena, on how extant or proposed traffic facilities may affect future utilization, on acceleration noise, on reactional and observational time lags that affect both driver and potential control systems, or on psychological and economic considerations. Yet all these are of direct importance to a constructive understanding of any physically meaningful theory of road traffic flow. Nevertheless, despite these limitations, the book is a stimulating, pioneering work. I imagine that it will entice or irritate others into competition.

WALTER HELLY

The Port of New York Authority

RUTH F. BLAISDELL, RONALD J. BOOSER, HELENE DECHIEF, MARION R. HERZOG, BEVERLY HICKOK, BRIGITTE L. KENNEY, DOROTHY V. RAMM, MARY L. ROY, MARGARET L. SULLIVAN and MARIANNE YATES, *Sources of Information in Transportation*, The Transportation Center, Northwestern University, 1818 Hinman Ave., Evanston, Illinois. 60204, 1964, 272 pages, \$5.00 (paper)

AS suggested by the title, this book is not exactly a bibliography. Some of its 1,712 entries are indeed references to particular books and papers on various aspects of transportation, but many are not. For example, 339 of the entries are simply names of periodicals, together with the city of publication and frequency of appearance. Many others refer to complete sets of government or quasi-official publications. For this reason, and also because of certain difficulties in arrangement, the work will probably be more useful as a preliminary volume for digging out some obscure information than for quick reference to known or nearly known texts.

The ten chapters that comprise the book are (number of entries in parentheses): General (133), Highways (460), Motor Carriers (91), Metropolitan Transportation (146), Railroads (237), Pipelines (144), Merchant Marine (102), Inland Waterways (224), Air Transportation (95), Missiles and Rockets (80).

Since each chapter is the work of a different author, the emphasis and quality vary considerably. For example, 36 of the 91 entries in the chapter on motor

carriers are US Government publications, and 30 others are issued by national associations, so that these official sources account for over 70 per cent of the total. The only really bad chapter is "Missiles and Rockets," which, in addition to being an absurd subject in the context of transportation, contains such entries as: LOÈVE, *Probability Theory*; BELLMAN, *Adaptive Control Processes*; JASIK, *Antenna Engineering Handbook*; FIFER, *Analog Computation*; CONN AND AVERY, *Infrared Methods*. Certain other chapters also contain rather far-fetched entries: *Vocabulary of Railroad Lingo*, *Financing the Natural Gas Industry*, *Flood*, *Pilotin' Comes Natural*, *The Dammed Missouri Valley*, *One-Sixth of a Nation*.

All of the chapters are divided into sections, and several into subsections and even subsubsections. Since entries are alphabetized within the smallest division, it is usually very difficult to find a particular item, even if it is known to be in the book. The chapter on highways is most extreme in this respect, comprising 55 separate alphabetizations. If we look under the section headed "Statistical Sources," subsection "General," subsubsection "Foreign," subsubsubsection "England," we find but two entries, hardly a good representation of general statistical information on transportation on the highways of England. Indeed, the entire subsubsection "Foreign" contains but one other entry, a Canadian one.

The total number of alphabetizations in the whole book is 205, and some are by publisher and some by author; on pp. 94-5 there are examples of both.

Each of the chapters except the first is introduced by a brief statement. A few of these state clearly the composition of the list to follow, but the majority are purely fatuous, containing such statements as "The related areas which should be investigated depend on the particular interest in research," or "the pipe line supplies a highly specialized and in some respects unique method of transportation." The criterion for inclusion in the chapter on inland waterways is stated to be "sources of information . . . most commonly used . . . in the Dravo Corporation."

There appears to be a good deal of duplication in the entries. The *Engineering Index* accounts for at least six identical entries, the report of the 1960 Woods Hole Conference for three, the US Government Publications Monthly Catalog for at least three, PROF. BENDTSEN's book for two, etc.

Most of the annotations are brief and sensible; in this respect the book certainly fulfills its intention. The whole publication (reproduced by offset from a typescript), has been spectacularly well typed and proofread, and the reviewer was not able to find a single error. However, all diacritical marks in foreign languages are omitted.

FRANK A. HAIGHT
University of California,
Los Angeles

A. KAUFMANN AND G. DESBAZEILLE, *La Méthode du Chemin Critique—Application aux Programmes de Production et d'Études de la Méthode P.E.R.T. et de ses Variantes*, Dunod, Paris, France, 1964, 180 pages, 25 francs (paper)

THIS monograph (whose title can be translated as *The Critical Path Method—Application of the PERT Method and its Variants to Programs of Production and Planning*) provides an introduction to the now-classical methods of time-only

PERT, etc.) and cost-time (CPM, etc.) project scheduling, in which a network is used to describe the partial ordering between the jobs or activities of the project. The scope of the book is fairly indicated by the main headings of its table of contents, plus some of the subtopics listed there:

Chapter 1. *Graphs and Orderings*. A graph, strict order relations in a connected graph without circuits [cycles], decomposition of a graph into levels, finding an ordering.

Chapter 2. *Establishing a Research or Production Program*. Representation of a program by a graph, critical path, float intervals and job margins, finding the critical path [two algorithms and one numerical example], two examples of application, jobs with random duration.

Chapter 3. *Generalization of the PERT Method* [à la H. EISNER, *Opns. Res.* 10, 15 (1962)].

Chapter 4. *Optimization of the Cost Economic Function*. Decreasing the total cost of a program, acceleration of a program at least cost [numerical example], arbitrary variation of operating cost as a function of the duration, linear variation and the parametric linear program, FULKERSON's [AND KELLEY's] algorithm, details of the iterative procedure, example, optimization of a program when the durations of the jobs are random variables [not really].

Appendices.

The β Distribution.

Mean Value of a Critical Path [à la D. R. FULKERSON, *Opns. Res.* 10, 808 (1962)].

Activity Subdivision and Realization of a Schedule [à la T. L. HEALY, *Opns. Res.* 9, 341 (1961)].

As in other works by KAUFMANN, the main strengths of this monograph are that it is timely, the explanations are clear, and the authors do not hesitate to give detailed numerical examples. Certainly the exercise involved in searching all of the current literature to extract the PERTinent points was very tedious, and the authors are to be commended for eliminating most of the sophomoric philosophy and black magic present in most popularized accounts of the subject. The reviewer is in complete agreement with E. VENTURA, who states in the preface

I am inclined to think that [the critical path method's] success is, in a large part, due to the fact that, in contrast to the other methods of OR, it does not require a previous elaborate mathematical training, and makes use of concepts which are fairly intuitive,

and with the authors' conclusion that

the critical path method in application favors "exactness," "clairvoyance," and also "audacity"; it is a good example of the use of mathematics in management.

To this reviewer, it was interesting to see how English terms correspond to those in French. To avoid the Academic conflict of *minimer* versus *minimaliser*, the authors use [MIN] throughout; for 'labelling', they use, variously, *étiquetage*, *affichage*, and *marquage*. Students of graph and network flow theory should be warned that *arc*, *arête* [edge], *chemin* [path], *chaîne*, and *circuit* are sometimes used differently than in the US literature. *Ordonnancement* can mean simply 'arrangement in regular order,' or, in OR contexts it can mean 'sequencing' or 'scheduling,' or both. Technical French is changing, also: in addition to the obvious coinings

bétonnage [concreting], *habillage* [making ready], *compactage* [compacting], it is also apparently proper to refer to *grutage* ['craning']. Sometimes the French is better; how marvelous it would be to have a title like *organisateur*, or *planificateur*! The 'float' or 'slack' associated with jobs becomes *marge libre*, *marge totale*, or *marge certain*, which makes a happy distinction with the slack in an event, which is simply *intervalle de flottement* (except in a marvelous typographical error on p. 42, where it becomes *intervalle de frottement*!).

There is some unevenness in the presentation.

- The very first sentence of the book is, approximately: "Without abusing the theoretical aspects of finding ordinal relations in a graph, this concept being, as we shall see, none other than a set of elements between which oriented connections exist, we think that it is suitable to recall certain terms from graph theory, and to show how to use various procedures permitting one to achieve ordinal relations." Even assuming the authors wish to avoid philosophy, it seems a small amount of motivation would be welcomed at this point by the nontechnical reader.

- Surely not all the graph-theoretic concepts in Chapter I and the set-theoretic notation in Sections 2, 10, 18, 27, 28, and Appendix II are needed to state the algorithms, since no proofs are given, and the examples presented do not require it.

- Also, giving a separate Chapter to EISNER's *Generalization* and Section 20 to *The Entropy Function* seems maladroit, when the space could better have been used to explore cost-time methods, explain parametric studies, discuss resource loading, give a list of available computer codes, or discuss other important omitted topics.

This reviewer also feels there are some pedagogical limitations in the monograph.

- For example, the reader is assumed to know about linear programming, duals, and network-flow theory, but this knowledge is never used, since nothing is proven. In fact, the two examples of cost-time solutions only show cases where the jobs are continually compressed (or remain fixed) as the project time decreases. Pity the poor reader who tries an example of his own, and finds some job being *extended* (bounded flow variable re-entering the basis)!

- As a personal bias, the reviewer feels that the Beta distribution is, as usual, over-emphasized. The authors are never quite clear as to what a random job duration means (a one-shot 'personal probability'?), whether the scheduling is to be performed before or after the job durations are known, what corrective action will be taken if the scheduling is incorrect, and so on. The analysis of Section 32, which purports to carry out cost-time optimization with random job durations, is in fact misleading, unless one reads very carefully between the lines to find out the real assumptions of the analysis.

Thus, although the monograph provides a good survey and clarification of the existing literature, the feeling persists that the authors have not completely integrated the material with their own experience, or added research results of their own.

Finally, the reviewer had hoped that a little chauvinism would be shown in discussing French research in the critical-path area. Although little known outside France, the contributions of B. Roy and others, beginning from graph theory and yet motivated by real scheduling problems, provided a parallel and coincident

stream of independent scheduling methods, quite similar to the American developments described in this book (see, for example, B. Roy, "Contribution de la théorie des graphes à l'étude de problèmes d'ordonnement," *Proc. Second International Conf. on Opnl. Res.*, pp. 171-185, Wiley, New York, 1961).

Summary of Tasting: A faithful pressing by a well-known *château* of a famous tock imported from California. *Body:* adequate. *Color:* clear, some sediment. *Bouquet:* heady. *Alcoholic content:* high, some residual fermentation. *Price:* popular. *Conclusion:* needs more maturing.

W. S. JEWELL

University of California

ROY, P. PACAUD, J. de ROSINSKI, D. CARRÉ, Ph. GUITART, P. DARNAUT, G. SANDIER, and Ph. TUAN NGHIEM, *Les Problèmes d'Ordonnement—Applications et Méthodes*, Dunod, Paris, France, 1964, 151 pages, 19 francs (paper)

THIS monograph on scheduling problems may conveniently be regarded as a supplement to the one described in the previous review; it provides further elaboration of critical path methods, showing how the theory may be extended somewhat to include other problems of scheduling, and providing several clear, interesting examples of French application of these methods. To a certain extent, this monograph answers the objection in the previous review that the earlier book did not sufficiently stress early French contributions to the area of project scheduling. Part of this seeming reluctance is, of course, due to the fact that our emphasis on 'publish or perish' has yet to reach the Continent.

The monograph's *raison d'être* is given in its foreword:

It is observed, when scanning specialized journals of all types, that scheduling problems are beginning to take on increasing importance. Not only the mathematicians work increasingly each day on theoretical plans, but even industrialists hesitate less and less in confiding to operational *chercheurs* the difficulties they meet with in their planning.

These works remaining, nevertheless, very dispersed, the French Operations Research Society [SoFRO] judged it desirable to assemble into a single volume a certain number of texts, for the most part already published on the occasion of seminars, colloquia, or congresses, which would form a sample of French work achieved during recent years in the domain of industrial applications, as well as in theoretical research. Thus, we hope to offer to the reader, in a relatively limited number of pages, the means to get an idea of the current state of the entire subject.

Because of the variety of the various contributions to the monograph, we shall discuss each chapter separately.

Chapter 1. *Physiognomy and Features of Scheduling Problems* (B. Roy). This introductory article describes the general problem of scheduling "something" by decomposing it into "tasks," and then choosing a starting time and duration for these tasks. This choice is limited by three principal types of constraints, which Roy calls "potential" (PERT-type), "disjunctive" (mutually exclusive use of facilities), and "cumulative" (resource loading). The article concludes with a comparison of the two types of graphs that may be used to describe the partial

orderings of the tasks: "task-potential" graphs (those used by Roy and co-workers), and "stage [event]-potential" graphs, (the familiar 'arrow' diagram used in the USA).

Chapter 2. *Operations Research in Construction* (P. PACAUD). This chapter is primarily an extended example of the use of critical-path methods in constructing an industrial building with five bays. Some attention is devoted to the possible savings in decomposing the various 'critical' operations for the entire building into jobs for the individual bays, thus reducing total time. There is also discussion of direct and indirect costs in building as a function of the total job duration.

Chapter 3. *Scheduling of Operations and Personnel in Using Coffering Tunnels* (J. DE ROSINSKI). An industrial construction example is described which consists of repeated use of "coffering-tunnels" in building up successive stories of the main framework of an apartment building. The primary limitation in using critical-path methods is the need to use a crane during "rotation," when the "tunnels" are put in place on the new "cell" to be concreted. This imposes a "disjunctive" constraint, which is solved by heuristic means. Another limitation on possible schedules is the need to maintain a proper "rhythm" of "work cadence," i.e., to schedule the manpower shifts, number of men in a given area, lunch times, etc., in a realistic, repetitive manner.

Chapter 4. *Maintenance Scheduling in a Refinery* (D. CARRÉ). A general discussion of the critical-path method as used to schedule planned maintenance in a refinery, attempting a realistic evaluation of the advantages and disadvantages of the method.

Chapter 5. *Scheduling Outfitting Operations at Chantiers de l'Atlantique* (PH. GUITART). The principal engineer of *Chantiers de l'Atlantique* describes the problems of scheduling the outfitting of the liner "France," solved with the aid of the Société d'Économie et de Mathématiques Appliquées (SEMA) and the Compagnie des Machines Bull. In this application the technological sequence problem was secondary to the problem of maintaining a smooth manpower-loading curve of the various manpower "corporations": "metalwork," "woodwork," "ventilation," "piping," "painting," "electricity," and "sail-making." Because of the many internal and external constraints on the "starting date" and "elasticity" (rate of work) of each job, the schedule was found by means of a "segmented" form of linear programming, which permitted rapid visualization of the manpower-loading curves, and selection of a desirable schedule. Even though it was at first thought possible to find a "best" solution directly—

... indeed, it is impossible to define a numerical indicator which permits one to satisfactorily classify the various possible schedulings relative to each other. For, whatever the definition of this indicator, there will always correspond a well-defined value for a given schedule; but, unfortunately, the converse is not true.

Chapter 6. *Contribution of the Theory of Graphs to the Study of Scheduling Problems* (B. ROY). This article is essentially the paper presented to the Second International Conference on Operational Research at Aix-en-Provence in 1960 (and referred to in the previous review). It is of interest primarily because it indicates the early French developments in scheduling theory, which were surprisingly

parallel to (and in some senses better than) the early American PERT developments.

Chapter 7. *Using the Fortran-Compiled List-Processing Language in the Solution of a Scheduling Problem* (P. DARNAUT AND G. SANDIER). This article describes the use of a list-processing language in developing a computer program for solving PERT-type problems; it is stated that this type of language is advantageous in retaining a compact description of the network in rapid-access memory. The program written for an IBM 7090 handles 3,000 jobs, and gives the starting dates "wedged to the right and to the left," i.e., both "earliest" and "latest."

Chapter 8. *Scheduling Problems with Disjunctive Constraints* (PH. TUAN NGHIEM). The last chapter studies the problem of "disjunctive" constraints in scheduling problems when jobs belonging to certain sets are required to be carried out during disjoint intervals of time, as for example, jobs using the same resource.

The set of minimal schedulings is studied and a procedure is found which permits one to move over the interior of this set, which has the structure of an *arborescence* [forest], by passing from one schedule to all of its successors by a simple change in the order of carrying out the tasks subject to the disjunctive constraints.

All in all, this collection represents an interesting group of articles written at a consistently intelligent, yet uncomplicated, level—something that is not true of most American articles on scheduling. If the future finds the French publishing more of their applied research, we shall have welcome and high-level competition.

It is interesting to note that this monograph resulted from a study group organized by the *Société Française de Recherche Opérationnelle* (SoFRO), but that this group merged in March 1964 with the *Association Française de Calcul et de Traitement de l'Information* (AFCALTI) so that the monograph has the imprimatur, as No. 2 in their *Monographies de Recherche Opérationnelle* series, of the combined organization, *Association Française d'Informatique et de Recherche Opérationnelle* (AFIRO), 7ter, Rue de la Chaise, Paris, 7ième, France. Is this also a trend of the future?

Summary of Tasting: An interesting variety of French *amuse-gueule*, very suitable for a *dégustation* with *La Méthode du Chemin Critique*.

W. S. JEWELL

University of California

FREDERIC M. SCHERER, *The Weapons Acquisition Process: Economic Incentives*, Division of Research, Graduate School of Business Administration, Harvard University, Boston, Massachusetts, 1964, 469 pages, \$7.50

HOW DOES the world's greatest military power acquire its advanced weapons? Is our weapons acquisition process efficient, or does it need basic alteration?

To answer these '64 billion dollar questions,' Harvard University's Weapons Acquisition Research Project has gathered considerable data, including a dozen major case studies. A preceding volume (MERTON J. PECK AND FREDERIC M. SCHERER, *The Weapons Acquisition Process: An Economic Analysis*, same publisher, 1962) focused on the first question; this volume deals with the second.

Scherer analyzes the government's problem of maintaining incentives for efficient and optimal program execution in the essentially nonmarket environment of weapons development and production. Assessing two broad classes of incentives—"competitive incentives," which correlate sales with contractor performance, and "contractual incentives," which correlate contract profits with performance—he finds a serious imbalance in the over-all incentive structure: Incentives to 'maximize' quality and to 'minimize' development time are powerful, but incentives to reduce costs are weak.

To redress the balance, Scherer proposes that incentive contracts emphasize the cost dimension, rather than the quality and time dimensions, of contractor performance. He also proposes after-the-fact evaluations, by competent and objective boards, of the over-all performances of contractors in major development programs. A contractor's profits, or his future sales, could be made dependent on these evaluations. Scherer is well aware of the controversial nature of these proposals, and of the difficulties of implementation, but he is also aware that improved incentive systems must be found "before it will be possible to reverse the trend toward increasingly detailed direct government control and supervision of contractor operations."

The volume will be interesting to a wide audience. Scherer's analysis of the motivations of aerospace firms, as reflected at the bargaining table and in over-all corporation policy, will interest both the theoretical economist and the pragmatic government official. The evidence suggests that neither short-run accounting profit, nor even long-run expected profit, can be used as a sufficient approximation of corporation goals when we are assessing the probable impact of government incentive policies.

Similarly, Scherer's illumination of the many facets of 'competition' in the peculiar setting of weapons development should be of general interest. Its potentialities, limitations, and possible distortions in this unique environment receive perceptive treatment. His suggestion that 'excess profits' are avoided by aerospace firms, either by transforming profits into costs, or by negotiating safer incentive formulas, has implications which government contracting officers and the Renegotiation Board should consider. His evidence suggesting that cost underruns on incentive contracts are the result of easy targets, rather than strong incentives, warrants attention from those economists and public officials making exaggerated claims for incentive contracts.

In writing this book, Scherer has struggled valiantly, not only with his moral conscience, but also with his scholarly ideals. Statistical and analytical power, like military power, is too often a temptation to ambition, or to overweening confidence, or to ostentatious displays, rather than a summons to painstaking care and responsibility. Here scholarship holds the upper hand throughout.

Naturally enough, few readers will agree fully with Scherer's diagnosis or prescription. This reviewer, for example, doubts that the cost dimension of contractor performance can be meaningfully separated from the quality and schedule dimensions. Cost control, quality control, and schedule control are too interdependent—unless by 'cost control' we mean simply the avoidance of carelessness and obvious waste. But a good book cannot be fairly summarized, let alone fairly

debated in a brief review. Suffice it to say that few readers will fail to benefit from this conscientious effort to apply rigorous analytic techniques to a highly complex—and extremely important—national problem.

ROBERT E. BICKNER
The Rand Corporation

EDWARD B. ROBERTS, *The Dynamics of Research and Development*, Harper and Row, New York, 1964, 352 pages, \$10.95

THIS BOOK provides the first application of industrial dynamics (see JAY W. FORRESTER, *Industrial Dynamics*, The MIT Press, Cambridge, Massachusetts, 1961) to research and development (R and D) management problems in industry and government. ROBERTS has succeeded in structuring the R and D process and has used dynamic decision models, together with information-feedback models and computer simulations, to develop a new method for the study of its problems.

Industrial dynamics has developed a method for solving industrial problems consisting of nine phases (p. 317):

1. Problem identification.
2. Verbal description of the dynamic system theory affecting the problem.
3. Mathematical model development.
4. Computer simulation of the represented system.
5. Analysis of results to determine model validity and factor sensitivity.
6. Double checking of, and data collection regarding, the sensitive areas of the model.
7. Simulation experimentation to help identify improved system parameters and policies.
8. Implementation of results of investigation in the real-world problem areas.
9. Evaluation of the effectiveness of the changes, and return to the first phase of procedure (item 1) for continuing improvement, if necessary.

Roberts's book applies this approach to R and D: The basic element of his study is a mathematical model that describes R and D project life cycles. The equations that are derived from an analysis of published and unpublished studies are considered to represent the relations underlying a typical R and D project; they are written in a form that is suitable for simulation on a digital computer, using the DYNAMO compiler. Life cycles of more than 1000 R and D projects are obtained from the computer simulations. A project life cycle is a time-dependent function representing costs, manpower effort, and information growth.

The model is based on the following description of the R and D process (p. 304):

1. Perception of the need for a new product by both the customer and the firm.
2. Estimation by both the customer and the firm of the amount of manpower effort required to develop the product.
3. Estimation of costs corresponding to the expected effort.
4. Firm's request for financial support by the customer.
5. Customer's evaluation of the request with respect to the expected cost-value character of the proposed project, leading to possible commitment of customer funds.
6. Instead of, or in addition to, the request for funds from the customer, the firm may initiate investment of its own funds in the project.

7. Undertaking of project effort, including the assembling of an engineering staff.
8. Employment of the technical staff and the resultant accomplishment of job progress.
9. Attempt at assessing the degree of project progress.
10. Reformulation of project effort estimates and value estimates, based on the newly achieved project know-how, producing re-evaluation of the suitability of the project for continued investment by the customer or the firm, or both.
11. Continuation of the above ten activities until the desired results, have been achieved and the job has been completed—or until the project has been cancelled.

Part I of the book is devoted to the development of a general theory of the R and D project. Chapter 1 presents the general structure of R and D projects viewed as dynamic systems. Chapter 2 develops the model equations and parameters for the product-value perception process in the firm. Analyses of the problems associated with the estimation of effort and cost of R and D projects lead to equations and parameters in Chapter 3. The process in which the firm attempts to obtain financial support for R and D projects, the customer evaluates the firm's request, and the firm makes R and D investment decisions is modelled in Chapter 4. Chapter 5 develops equations for the acquisition and utilization of engineering manpower that involves such factors as recruitment policies, training policies, transfer policies, experience effects, organizational size, and managerial effectiveness. Equations are developed in Chapter 6 for use in the evaluation of progress and control of R and D projects. In Chapter 7, the final chapter of this part, the author identifies the following potential determinants of R and D project life cycles (p. 209):

1. *Characteristics of the Product*
 - (a) Intrinsic product value
 - (b) Intrinsic size of the job
 - (c) Rate of growth of related technology
2. *Characteristics of the Firm*
 - (d) Managerial and technical ability
 - (e) Willingness to accept risks
 - (f) Previous job-size experience
 - (g) Integrity
 - (h) Criteria for project selection
 - (i) Availability of funds
3. *Characteristics of the Customer*
 - (j) Confidence in the firm
 - (k-p) All the factors listed above as characteristics of the firm

Part II presents analyses of the simulation of R and D projects utilizing the dynamic model derived in Part I. Chapter 8 analyzes the simulated time history of a project; it serves to illustrate the usefulness of the economic and time series that are analyzed in this part. Succeeding chapters deal with the effects of the determinants by making changes in their values and producing new simulated life cycles. Chapter 9 is concerned with the effects of product characteristics, job size, product value, and product technology. In Chapter 10 the effects of a firm's

quality, willingness to accept risk, integrity, and financial limitations are investigated. The customer's influence, as expressed through such customer factors as quality, risk propensity, previous experience, integrity, financial limitations, and confidence in the firm, are examined in Chapter 11. Organizational growth requirements, training policies, growth rates, and size are analyzed in Chapter 12. Chapter 13 presents a summary of the major results and recommends additional studies in the areas of model construction and data collection.

Roberts has made a significant contribution to the methodology of 'research-on-research.' He has succeeded in combining the social, psychological, technical, and economic factors into a unified theory of the R and D project. Other available studies have been used to validate equations and estimate parameter values. The model, simulation technique, and the systems approach that are developed in this book will be used by researchers to obtain deeper understandings of and optimization procedures for the R and D process.

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Books Received

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JAMES R. BRIGHT, *Research, Development, and Technological Innovation*, Richard D. Irwin, Inc., Homewood, Illinois, 1964, 801 pages, \$13.35.

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RICHARD H. DAY, *Linear Programming and Related Computations: A Guide to USDA LP/90*, Farm Production Economics Division, Economic Research Service, US Department of Agriculture, Washington, D. C. 20250, 1964, 285 pages, no price (paper).

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- E. LUKACS AND R. G. LAHA, *Applications of Characteristic Functions*, Hafner Publishing Co., New York, N. Y., 1964, 202 pages, \$7.25.
- NATIONAL SCIENCE FOUNDATION, *Federal Funds for Research, Development, and Other Activities: Fiscal Years 1962, 1963, and 1964, Volume XII*, NSF 64-11, Superintendent of Documents, US Government Printing Office, Washington, D. C., 20402, 1964, 188 pages, \$1.00 (paper).
- , *Research and Other Activities of Private Foundations: 1960*, NSF 64-14, Superintendent of Documents, US Government Printing Office, Washington, D. C. 20402, 1964, 44 pages, 35 cents (paper).
- CHARLES D. ORTH, 3RD, JOSEPH C. BAILEY, AND FRANCIS W. WOLEK, *Administering Research and Development: The Behavior of Scientists and Engineers in Organizations*, Richard D. Irwin, Inc., Homewood, Illinois, 1964, 595 pages, \$11.95.
- EUGENE D. PERLE, *The Demand for Transportation: Regional and Commodity Studies in the United States*, Department of Geography, University of Chicago, Chicago, Illinois, 1964, 150 pages, no price (paper).
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- B. ROY AND OTHERS, *Les Problèmes d'Ordonnancement—Applications et Méthodes*, Dunod, Paris, France, 1964, 151 pages, 19 francs (paper).
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N. N. AGARWAL, "Dependability of an Intermittent System"

Y. K. KONENKOV AND I. A. USHAKOV, "Evaluation of the Operational Effectiveness of Branching Systems with Symmetrical Structure"

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L. R. AMEY, "The Allocation and Utilization of Resources"

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PAULA M. J. HARRIS, "An Algorithm for Solving Mixed Integer Linear Programmes"

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ROBERT M. OLIVER, "Travel Times through Shock Waves"

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K. THIRUVENGADAM AND N. K. JAISWAL, "Application of Discrete Transforms to a Queuing Process of Servicing Machines"

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JACQUES AGARD, "Gestion des pièces de rechange dans les Compagnies aériennes"

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- A. CHARNES AND M. KIRBY, "The Dual Method and the Method of Balas and Ivanescu for the Transportation Model"
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Trabajos de Estadística y de Investigación Operativa, Vol. 15 (1964) No. 1

- B. M. BENNET AND B. BIRCH, "Sampling Inspection Tables for Comparison of Two Groups Using the Negative Binomial Model"
- PAUL VAN MOESEKE, "A Variational Note on 'Tatonnement' "
- A. VEGAS PEREZ, "Estimación no paramétrica de procesos monótonos"
- S. RIOS, "Problemas de inversiones, decisiones secuenciales, programación dinámica, procesos autoadaptativos"

The Journal of Industrial Engineering, September-October 1964

- C. WILLIAM ANDERSON, "Industrial Engineering in a Telephone Company"
- PAUL W. BENNINGTON, "Industrial Engineering Practices at The Steel Company of Canada"
- ROBERT J. CUMMINGS, "Industrial Engineering at Union Bag-Camp Paper Corporation's Savannah Complex"
- T. BLAIR EVANS, "Industrial Engineering in Air Force Logistics"
- CLIFFORD GEHRT, "Industrial Engineering at Wagner Castings"
- BERTRAM GOTTLIEB, "Unions and Industrial Engineering: Policies and Practices"
- ROBERT H. HORN, "A Growing Industrial Engineering Department"
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- S. IAN RASTALL, "The Industrial Engineering Function in Branch Banking"
- ROBERT J. ROHR, "Industrial Engineering as Practiced in the Kodak Park Works, Eastman Kodak Company"
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- P. E. HAGGERTY, "Research Management—a Survival Issue"
- MARSHALL HALL, "The Determinants of Investment Variations in Research and Development"
- WILLIAM H. POUND, "Research Project Selection: Testing a Model in the Field"

DONALD C. PELZ, "The 'Creative Years' and the Research Environment"

JOHN F. McNEIL, "Program Control Systems"

GEORGE POLETTI, "The Diffusion of Network Techniques Throughout Government Publications" (This article includes a bibliography of 170 items)

EDITORIAL NOTES

RECENT years have seen a tremendous growth in the literature of operations research, both in books and periodicals.

To provide operations research workers with convenient current coverage of the world-wide periodical literature, ORSA founded *International Abstracts in Operations Research*, a journal that is now completing its fourth year under the sponsorship of the International Federation of Operational Research Societies.

Since the editorship of *The Analyst's Bookshelf* changed hands in the summer of 1963, over 200 books have been received for review, well over half of which deserve serious attention in our pages. To make room for the appropriate expansion of our book-review coverage, two changes will be made in *The Analyst's Bookshelf*, effective with the first issue in 1965:

- The contents of other journals will no longer be listed, since *IAOR* can be expected to give readers prompt and more complete coverage of this material.

- The abstracts of doctoral theses will no longer be printed. (Such items should henceforth be sent to the appropriate Contributing Editor of *IAOR*.)

Thus, in future issues *The Analyst's Bookshelf* will have three parts: book reviews, listings of books received, and notes on miscellaneous publication items of unusual interest.

PREVIOUS VOLUMES of *Operations Research* have indexed the reviewers of books but not the authors of the books reviewed. Thus, following these notes there appears an *Index of Authors of Books Reviewed* for Volumes 1-12, 1952-1964.

THE EDITORS of the *Naval Research Logistics Quarterly* have announced that back issues of their journal for the 10 years 1954-1963 will henceforth be available from the Johnson Reprint Corporation, 111 Fifth Avenue, New York 3, N. Y.