

COMPLETELY REVISED *AND* UPDATED

HANDBOOK OF INDUSTRIAL ENGINEERING

Technology and
Operations
Management

Third Edition

Edited by

GAVRIEL SALVENDY

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Purdue University



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FOREWORD

Many people speculated about what industrial engineering might look like in the 21st century, and now here we are. It is exciting to see how the profession's definition of the work center has broadened to embrace the information age and the global economy. Industrial engineers, with their ever-expanding toolbox, have a greater opportunity to help corporations be successful than ever before.

But while these changes and opportunities are exciting, they presented a challenge to the editor of this handbook. I met with Gavriel Salvendy as he began working to integrate all the thoughtful input he had received from his advisory committee, so I had a firsthand opportunity to observe the energy and creativity required to develop this content-rich edition. This handbook is truly an accomplishment, fully supporting industrial engineers engaged in traditional as well as new facets of the profession.

This edition has stepped up to this multidimensional challenge. The Technology section updates the previous edition, with coverage of topics such as decision support systems, but also delves into information-age topics such as electronic commerce. Look closer and you'll see that attention has been given to the growing services sector, including chapters covering specific application areas.

"Enterprise" has become a popular way to describe the total system and the broad organizational scope of problem-solving initiatives. I am pleased to see this addressed specifically through topics such as enterprise modeling and enterprise resource planning, as well as globally, as in the Management, Planning, Design, and Control section. This edition truly recognizes that IEs can and do contribute in every phase of the total product life cycle.

The mission of the Institute of Industrial Engineers is to support the professional growth of practicing industrial engineers. This third edition is an all-encompassing Handbook for the IE professional that rises to the task. Students, engineers of all types, and managers will find this a useful and insightful reference.

JOHN POWERS
Executive Director
Institute of Industrial Engineers

PREFACE

Industrial Engineering has evolved as a major engineering and management discipline, the effective utilization of which has contributed to our increased standard of living through increased productivity, quality of work and quality of services, and improvements in the working environments. The *Handbook of Industrial Engineering* provides timely and useful methodologies for achieving increased productivity and quality, competitiveness, globalization of business and for increasing the quality of working life in manufacturing and service industries. This Handbook should be of value to all industrial engineers and managers, whether they are in profit motivated operations or in other nonprofit fields of activity.

The first edition of the *Handbook of Industrial Engineering* was published in 1982. It has been translated into Japanese and published by the Japan Management Association; translated into Spanish and published by Editorial Lemusa; published in a special edition in Taiwan by Southeast Book Company; and translated into Chinese and published by Mechanical Industry Publisher; and adopted by the Macmillan book club. The Handbook was selected by the Association of American Publishers as the Best Professional and Scholarly Publication in 1982 and was widely distributed by the Institute of Industrial Engineers (IIE). The Foreword of the first edition of the Handbook was written by Donald C. Burnham, retired Chairman of Westinghouse Electric Corporation. In this Foreword Burnham wrote, "The Industrial Engineering principles that are outlines are timeless and basic and should prove useful to corporations, both large and small, both continuous process as well as discrete part manufacturing, and especially to those working in the service industries where most of the jobs are today." The second edition of the *Handbook of Industrial Engineering* maintained this thrust.

In the Foreword to the second edition, the former president of NEC Corporation wrote, "The Second Edition of the Handbook of Industrial Engineering will serve as an extremely powerful tool for both industrial engineers and managers." The many contributing authors came through magnificently. I thank them all most sincerely for agreeing so willingly to create this Handbook with me.

Each submitted chapter was carefully reviewed by experts in the field and myself. Much of the reviewing was done by the Advisory Board. In addition, the following individuals have kindly contributed to the review process: Stephan A. Konz, K. Ronald Laughery, Jack Posey, William B. Rouse, Kay M. Stanney, Mark Spearman, and Arnold L. Sweet.

For the third edition of this Handbook, 97 of the 102 chapters were completely revised and new sections added in project management (3 chapters), supply-chain management and logistics (7 chapters) and the number of chapters in

service systems increased from 2 to 11 chapters. The 102 chapters of this third edition of the handbook were authored by 176 professionals with diverse training and professional affiliations from around the world. The Handbook consists of 6441 manuscript pages, 922 figures, 388 tables, and 4139 references that are cited for further in-depth coverage of all aspects of industrial engineering.

The editing of the third edition of the Handbook was made possible through the brilliant, most able, and diligent work of Kim Gilbert, my administrative assistant, who so effectively coordinated and managed all aspects of the Handbook preparation. My sincere thanks and appreciation go to her. It was a true pleasure working on this project with Bob Argentieri, the John Wiley senior editor, who is the very best there is and was a truly outstanding facilitator and editor for this Handbook.

GAVRIEL SALVENDY

*West Lafayette, Indiana
September 2000*

CONTENTS

I. Industrial Engineering Function and Skills	1
1. Full Potential Utilization of Industrial and Systems Engineering in Organizations, <i>by D. Scott Sink, David F. Poirier, and George L. Smith</i>	3
2. Enterprise Concept: Business Modeling Analysis and Design, <i>by Frank O. Marrs and Barry M. Mundt</i>	26
II. Technology	61
A. <i>Information Technology</i>	63
3. Tools for Building Information Systems, <i>by Robert M. Barker, Brian L. Dos Santos, Clyde W. Holsapple, William P. Wagner, and Andrew L. Wright</i>	65
4. Decision Support Systems, <i>by Andrew P. Sage</i>	110
5. Automation Technology, <i>by Chin-Yin Huang and Shimon Y. Nof</i>	155
6. Computer Integrated Technologies and Knowledge Management, <i>by Frank-Lothar Krause, Kai Mertins, Andreas Edler, Peter Heisig, Ingo Hoffmann, and Markus Helmke</i>	177
7. Computer Networking, <i>by Lajos Bálint and Tamás Máray</i>	227
8. Electronic Commerce, <i>by Soon-Yong Choi and Andrew B. Whinston</i>	259
9. Enterprise Modeling, <i>by August-Wilhelm Scheer, Frank Habermann, and Oliver Thomas</i>	280
B. <i>Manufacturing and Production Systems</i>	309
10. The Factory of the Future: New Structures and Methods to Enable Transformable Production, <i>by Hans-Jürgen Warnecke, Wilfried Sihn, and Ralf von Briel</i>	311
11. Enterprise Resource Planning Systems in Manufacturing, <i>by Mary Elizabeth A. Algeo and Edward J. Barkmeyer</i>	324
12. Automation and Robotics, <i>by Rolf Dieter Schraft, Jens-Günter Neugebauer, and Stefan Schmid</i>	354

13. Assembly Process, <i>by K. Feldmann</i>	401
14. Manufacturing Process Planning and Design, <i>by Tien-Chien Chang and Yuan-Shin Lee</i>	447
15. Computer Integrated Manufacturing, <i>by Cheng Wu, Fan YuShun, and Xiao Deyun</i>	484
16. Clean Manufacturing, <i>by Julie Ann Stuart</i>	530
17. Just-in-Time, Lean Production, and Complementary Paradigms, <i>by Takao Enkawa and Shane J. Schvaneveldt</i>	544
18. Near-Net-Shape Processes, <i>by Reimund Neugebauer and Klaus Herfurth</i>	562
19. Environmental Engineering: Regulation and Compliance, <i>by Robert B. Jacko and Timothy M. C. LaBreche</i>	589
20. Collaborative Manufacturing, <i>by José A. Ceroni and Shimon Y. Nof</i>	601
C. Service Systems	621
21. Service Industry Systems and Service Quality, <i>by Martin Wetzels and Ko de Ruyter</i>	623
22. Assessment and Design of Service Systems, <i>by Michael Haischer, Hans-Jörg Bullinger, and Klaus-Peter Fähnrich</i>	634
23. Customer Service and Service Quality, <i>by Richard A. Feinberg</i>	651
24. Pricing and Sales Promotion, <i>by Kent B. Monroe</i>	665
25. Mass Customization, <i>by Mitchell M. Tseng and Jianxin Jiao</i>	684
26. Client/Server Technology, <i>by On Hashida and Hiroyuki Sakata</i>	710
27. Industrial Engineering Applications in Health Care Systems, <i>by Swatantra K. Kachhal</i>	737
28. Industrial Engineering Applications in Financial Asset Management, <i>by R. McFall Lamm, Jr.</i>	751
29. Industrial Engineering Applications in Retailing, <i>by Richard A. Feinberg and Tim Christiansen</i>	772
30. Industrial Engineering Applications in Transportation, <i>by Chryssi Malandraki, David Zaret, Juan R. Perez, and Chuck Holland</i>	787
31. Industrial Engineering Applications in Hotels and Restaurants, <i>by Douglas C. Nelson</i>	825
III. Performance Improvement Management	837
A. Organization and Work Design	839
32. Leadership, Motivation, and Strategic Human Resource Management, <i>by Taly Dvir and Yair Berson</i>	841

33. Job and Team Design, by <i>Gina J. Medsker and Michael A. Campion</i>	868
34. Job Evaluation in Organizations, by <i>John M. Hannon, Jerry M. Newman, George T. Milkovich, and James T. Brakefield</i>	899
35. Selection, Training, and Development of Personnel, by <i>Robert W. Swezey and Richard B. Pearlstein</i>	920
36. Aligning Technological and Organizational Change, by <i>Ann Majchrzak and Najmedin Meshkati</i>	948
37. Teams and Team Management and Leadership, by <i>François Sainfort, Alvaro D. Taveira, and Michael J. Smith</i>	975
38. Performance Management, by <i>Martin P. Finegan and Douglas K. Smith</i>	995
B. Human Factors and Ergonomics	1011
39. Cognitive Tasks, by <i>Nicolas Marmaras and Tom Kontogiannis</i>	1013
40. Physical Tasks: Analysis, Design, and Operation, by <i>Waldemar Karwowski and David Rodrick</i>	1041
41. Ergonomics in Digital Environments, by <i>Ulrich Raschke, Lisa M. Schutte, and Don B. Chaffin</i>	1111
42. Human Factors Audit, by <i>Colin G. Drury</i>	1131
43. Design for Occupational Health and Safety, by <i>Michael J. Smith, Pascale Carayon, and Ben-Tzion Karsh</i>	1156
44. Human–Computer Interaction, by <i>Kay M. Stanney, Michael J. Smith, Pascale Carayon, and Gavriel Salvendy</i>	1192
IV. Management, Planning, Design, and Control	1237
A. Project Management	1239
45. Project Management Cycle: Process Used to Manage Project (Steps to Go Through), by <i>Avraham Shtub</i>	1241
46. Computer-Aided Project Management, by <i>Carl N. Belack</i>	1252
47. Work Breakdown Structure, by <i>Boaz Golany and Avraham Shtub</i>	1263
B. Product Planning	1281
48. Planning and Integration of Product Development, by <i>Hans-Jörg Bullinger, Joachim Warschat, Jens Leyh, and Thomas Cebulla</i>	1283
49. Human-Centered Product Planning and Design, by <i>William B. Rouse</i>	1296
50. Design for Manufacturing, by <i>C. Richard Liu and Xiaoping Yang</i>	1311

51. Managing Professional Services Projects, <i>by Barry M. Mundt and Francis J. Smith</i>	1332
C. <i>Manpower Resource Planning</i>	1351
52. Methods Engineering, <i>by Stephan Konz</i>	1353
53. Time Standards, <i>by Stephan Konz</i>	1391
54. Work Measurement: Principles and Techniques, <i>by Aura Castillo Matias</i>	1409
D. <i>Systems and Facilities Design</i>	1463
55. Facilities Size, Location, and Layout, <i>by James A. Tompkins</i>	1465
56. Material-Handling Systems, <i>by Yavuz A. Bozer</i>	1502
57. Storage and Warehousing, <i>by Jerry D. Smith</i>	1527
58. Plant and Facilities Engineering with Waste and Energy Management, <i>by James R. Ross</i>	1548
59. Maintenance Management and Control, <i>by Ralph W. "Pete" Peters</i>	1585
E. <i>Planning and Control</i>	1625
60. Queuing Models of Manufacturing and Service Systems, <i>by John A. Buzacott and J. George Shanthikumar</i>	1627
61. Production-Inventory Systems, <i>by David D. Yao</i>	1669
62. Process Design and Reengineering, <i>by John Taylor, Tarsha Dargan, and Ben Wang</i>	1695
63. Scheduling and Dispatching, <i>by Michael Pinedo and Sridhar Seshadri</i>	1718
64. Personnel Scheduling, <i>by Richard N. Burns</i>	1741
65. Monitoring and Controlling Operations, <i>by Albert T. Jones, Yuehwern Yih, and Evan Wallace</i>	1768
F. <i>Quality</i>	1791
66. Total Quality Leadership, <i>by Johnson A. Edosomwan</i>	1793
67. Quality Tools for Learning and Improvement, <i>by Lloyd Provost</i>	1808
68. Understanding Variation, <i>by Lloyd Provost</i>	1828
69. Statistical Process Control, <i>by John R. English and Terry R. Collins</i>	1856
70. Measurement Assurance, <i>by S. Chandrasekar</i>	1877
71. Human Factors and Automation in Test and Inspection, <i>by Colin G. Drury</i>	1887
72. Reliability and Maintainability, <i>by Kailash C. Kapur</i>	1921
73. Service Quality, <i>by Laura Raiman DuPont</i>	1956
74. Standardization, Certification, and Stretch Criteria, <i>by Harrison M. Wadsworth, Jr.</i>	1966

75. Design and Process Platform Characterization Methodology, by <i>Raja M. Parvez and Donald Fusaro</i>	1975
G. Supply Chain Management and Logistics	2005
76. Logistics Systems Modeling, by <i>David Simchi-Levi and Edith Simchi-Levi</i>	2007
77. Demand Forecasting and Planning, by <i>Ananth V. Iyer</i>	2020
78. Advanced Planning and Scheduling for Manufacturing, by <i>Kenneth Musselman and Reha Uzsoy</i>	2033
79. Transportation Management and Shipment Planning, by <i>Jeffrey H. Fischer</i>	2054
80. Restructuring a Warehouse Network: Strategies and Models, by <i>Hokey Min and Emanuel Melachrinoudis</i>	2070
81. Warehouse Management, by <i>Gunter P. Sharp</i>	2083
82. Supply Chain Planning and Management, by <i>Douglas M. Lambert and Edward A. Siecienski</i>	2110
V. Methods for Decision Making	2141
A. Probabilistic Models and Statistics	2143
83. Stochastic Modeling, by <i>Colm A. O’Cinneide</i>	2145
84. Decision-Making Models, by <i>Mark R. Lehto</i>	2172
85. Design of Experiments, by <i>H. Samuel Wang and Chung-Pu Chang</i>	2224
86. Statistical Inference and Hypothesis Testing, by <i>Don T. Phillips and Alberto Garcia-Diaz</i>	2241
87. Regression and Correlation, by <i>Raja M. Parvez and Donald Fusaro</i>	2264
B. Economic Evaluation	2295
88. Product Cost Analysis and Estimating, by <i>Phillip F. Ostwald</i>	2297
89. Activity-Based Management in Manufacturing, by <i>Keith V. Smith</i>	2317
90. Discounted Cash Flow Methods, by <i>Raymond P. Lutz</i>	2331
91. Economic Risk Analysis, by <i>G. A. Fleischer</i>	2360
92. Inflation and Price Change in Economic Analysis, by <i>Joseph C. Hartman</i>	2394
C. Computer Simulation	2407
93. Modeling Human Performance in Complex Systems, by <i>K. Ronald Laughery, Jr., Susan Archer, and Kevin Corker</i>	2409

94. Simulation Packages, by <i>Abe Nisanci and Robert E. Schwab</i>	2445
95. Statistical Analysis of Simulation Results, by <i>Barry L. Nelson</i>	2469
96. Virtual Reality for Industrial Engineering: Applications for Immersive Virtual Environments, by <i>Hans-Jörg Bullinger, Ralf Breining, and Martin Braun</i>	2496
D. <i>Optimization</i>	2521
97. Linear Optimization, by A. “Ravi” Ravindran and Roy Marsten	2523
98. Nonlinear Optimization, by <i>Tom M. Cavalier</i>	2540
99. Network Optimization, by <i>Richard T. Wong</i>	2568
100. Discrete Optimization, by <i>Ronald L. Rardin</i>	2582
101. Multicriteria Optimization, by <i>Po Lung Yu, Chin I. Chiang, and Gwo Hshiang Tzeng</i>	2602
102. Stochastic Optimization, by <i>Anton J. Kleywegt and Alexander Shapiro</i>	2625
Author Index	2651
Subject Index	2699