Guide to the

Engineering Management Body of Knowledge

Library of Congress Cataloging-in-Publication Data

Guide to the engineering management body of knowledge.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-7918-0299-1
1. Project Management—Dictionaries. 2. Project Management—Bibliography.
3. Technical Literature. I. American Society of Mechanical Engineers.
T56.8.G85 2010
658.5—dc22

2010017361

Table of Contents

TABLE OF CONTENTS III
LIST OF FIGURES V
PREFACE VIII
ACKNOWLEDGEMENTS IX
INTRODUCTION 12
PURPOSE 12
OVERVIEW 13
DOMAIN 1: MARKET RESEARCH, ASSESSMENT AND FORECASTING 27
1.1 Market Analysis 29
1.2 Best Practices and Lessons Learned 35
1.3 Business Research and Forecasting Tools and Techniques 38
1.4 Risk Analysis 41
1.5 Trend Analysis 46
1.6 Technology Assessment Practices and Techniques 50
1.7 Presentation Skills 54
DOMAIN 2: STRATEGIC PLANNING AND CHANGE MANAGEMENT 65
2.1 Strategic Destinations and Planning 68
2.2 System Design and Life-Cycle Engineering 75
2.3 Strategic Management 79
2.4 Partnering and Outsourcing Strategies 104
2.5 Financial Risk Management Strategies and Models for New Technologies 112
2.6 Change Management Techniques and Adjustment Strategies 117
DOMAIN 3: PRODUCT, SERVICE AND PROCESS DEVELOPMENT 125
3.1 Engineering Disciplines 127
3.2 Manufacturability 130
3.3 System Design Methodology and Life-Cycle Engineering Product/Process Creation 146
DOMAIN 4: ENGINEERING PROJECTS AND PROCESS MANAGEMENT 157
4.1 Project Selection 159
4.2 Project Management Techniques 164
4.3 Scheduling Techniques 172
4.4 Maintaining Customer Service and Satisfaction 174
4.5 Total Quality Management (TQM) 177
4.6 Project and Process Tools 181
DOMAIN 5: FINANCIAL RESOURCE MANAGEMENT 191
5.1 Procurement and Contract Procedures; Contract Management 193
5.2 Funding Sources 201
5.3 Financial Accounting and Budgeting Procedures 204
5.4 Engineering Economic Analysis Techniques 215
5.5 Inventory Control Procedures and Supply Chain Management 221
DOMAIN 6: MARKETING, SALES AND COMMUNICATIONS MANAGEMENT 227
6.1 Sales and Advertising Practices 229
6.2 Customer Satisfaction Strategies 234
6.3 Marketing and Branding Techniques 238

6.4 Product Portfolio Analysis 247
6.5 Global Trade and International Operations 252
6.6 Pricing Strategies 260
DOMAIN 7: LEADERSHIP AND ORGANIZATIONAL MANAGEMENT 267
7.1 Schools of Management Thought 273
7.2 Managing and Motivating Knowledge Workers 277
7.3 Organization Structure 293
7.4 Management Systems and Systems Thinking 303
7.5 Leadership 322
7.6 Human Resources Management 328
DOMAIN 8: PROFESSIONAL RESPONSIBILITY, ETHICS AND LEGAL ISSUES 347
8.1 Professionalism 349
8.2 Compliance Procedures 351
8.3 Regulatory Requirements, Codes, and Standards 354
8.4 Business Contract, Patent, Copyright, Trademark Laws, and Intellectual Property (IP) 364
8.5 U.S. and International Codes, Standards, and Regulations 368
COMMON ACRONYMS 381
GLOSSARY 387
INDEX 391

List of Figures

Figure 1- 1 Steps in the Marketing Research Process and Potential Sources of Error....30
Figure 1- 2 Examples of Quantitative and Qualitative Primary Research Methods....31
Figure 1- 3 SWOT and PEST Models of Data Analysis....33
Figure 1- 4 Structure, Content and Focus of a Market Analysis Report....33
Figure 1- 5 The Benchmarking Process....36
Figure 1- 6 Steps in Forecasting....39
Figure 1- 7 ROI Worksheet and Worksheet Summary....40
Figure 1- 8 Fishbone Cause and Effect Diagram....43
Figure 1- 9 Influence Diagram....44
Figure 1- 10 Trend Analysis Process....49
Figure 1- 11 Technology Assessment....50
Figure 1- 12 Characteristics of a New Technology Checklist....51
Figure 1- 13 The Communication Process....57
Figure 2- 1 Comprehensive Strategic Planning....68
Figure 2- 2 Issue-based Planning Example....69
Figure 2- 3 Sources of Competitive Intelligence....72
Figure 2- 4 New Product Introduction Checklist....73
Figure 2- 5 System Design Tools....76
Figure 2- 6 Flow Chart....76
Figure 2- 7 Data Flow Diagram....76
Figure 2- 8 Decision Table....77
Figure 2- 9 Decision Tree....77
Figure 2- 10 The Strategic Management Model....81
Figure 2- 11 The Boston Matrix....84
Figure 2- 12 The SWOT Matrix....85
Figure 2- 13 The Product Life Cycle....86
Figure 2- 14 The "Bath Tub" Curve....92
Figure 2- 15 Porter's Model....93
Figure 2- 16 Production Logic for Companies Organized around Core Competencies....99
Figure 2- 17 Reasons for Outsourcing....104
Figure 2- 18 The Nine Stages of Outsourcing Activity....108
Figure 2- 19 Outsourcing Relationship Issues....109
Figure 2- 20 Outsourcing Pricing Options....109
Figure 2- 21 Change Drivers....112
Figure 2- 22 Risk Identification Methods....112
Figure 2- 23 Impact Matrix....116
Figure 2- 24 Identification and Prioritization of Risks.....117
Figure 2- 25 Functional and Dysfunctional Conflicts....118
Figure 2- 26 Model of the Employee Decision to Actively Resist an Organizational Change Effort....119
Figure 3- 1 Sample Process Map....130
Figure 3- 2 Design for Manufacturability....133
Figure 3- 3 Seven Steps to Lean Operations....135
Figure 3- 4 The Focus of Total Quality Management (TQM)....136
Figure 3- 5 Six Sigma Process Flow....138
Figure 3- 6 HP Focus on Customer Requirements....141
Figure 3- 7 Robust Design: Making a Light Bulb....144
Figure 3- 8 Sample Design Structure Matrix....148
Figure 3- 9 Block Diagram from Superhetrodyning Receiver (Radio)....152
Figure 4- 1 Capital Expenditure Decision-Making Process....161
Figure 4- 2 Example of Risk Assessment Table....169
Figure 4- 3 Work Breakdown Scheduled Task Record....172

Figure 4- 4 Balance required for Successful Project Management....173
Figure 4- 5 Deming's 14 Points for Management....177
Figure 4- 6 Quality Management Tools....180
Figure 4- 7 Root Cause Summary Table....182
Figure 4- 8 Function Point Analysis....185
Figure 4- 9 Sample Project Management Software Evaluation....186
Figure 5- 1 Budget Flow Process....205
Figure 5- 2 Sample Cash Flow Diagram....208
Figure 5- 3 Sample Cash Flow Schedule....209
Figure 5- 4 Balance Sheet Components....213
Figure 5- 5 Profit and Loss Statement Elements....214
Figure 5- 6 Balanced Scorecard....218
Figure 5- 7 ERP Software Functions....222
Figure 6- 1 Producing Advertising....230
Figure 6- 2 Sales Process Steps....230
Figure 6- 3 Sales Plan Elements....233
Figure 6- 4 Five Dimensions of Behavioral Intention....235
Figure 6- 5 The Four P's of Marketing....238
Figure 6- 6 The Precision Marketing Cycle....239
Figure 6- 7 Marketing Plan Elements....241
Figure 6- 8 Market Segmentation Methods....242
Figure 6- 9 Marketing Effectiveness....243
Figure 6- 10 The Boston Matrix....248
Figure 6- 11 Balanced Product Portfolio....249
Figure 6- 12 Un-balanced Product Portfolio....249
Figure 6- 13 The Product Life Cycle....251
Figure 6- 14 Importance of Producing Successive Products....251
Figure 6- 15 Key Manager Tasks During the Five Stages of a Product Life Cycle....252
Figure 6- 16 International Business Operation Models....254
Figure 6- 17 International Operations....255
Figure 6- 18 Cultural Differences....257
Figure 6- 19 Pricing Strategies Matrix....261
Figure 6- 20 Common Product Pricing Methods....262
Figure 7- 1 Westbrook's Integrated Management Model....270
Figure 7- 2 Maslow's Hierarchy of Human Needs....279
Figure 7- 3 Motivation Diagram....282
Figure 7- 4 Traditional Organization Structure....285
Figure 7- 5 The Team-based Organization....286
Figure 7- 6 Message Loss in Top-down Communications....286
Figure 7- 7 Likert's Four Systems Compared....290
Figure 7- 8 The Managerial Grid....291
Figure 7- 9 Comparing the Results of Key Management Studies....293
Figure 7- 10 The Mintzberg Model....299
Figure 7- 11 The Machine Bureaucracy....301
Figure 7- 12 The Professional Bureaucracy....302
Figure 7- 13 Personal Mastery Model....312
Figure 7- 14 Characteristics of High and Low Context Cultures....334
Figure 7- 15 Phases of Conflict Resolution....338
Figure 7- 16 Strategies for Resolving Conflict....339
Figure 8- 1 Procedure Document Topics....352
Figure 8- 2 Benefits of Documentation....353
Figure 8- 3 Federal, State and Local Government Regulations Resources....356
Figure 8- 4 Examples of Safety Areas Regulated by OSHA....356
Figure 8- 5 Accessing Regulatory Requirements....358
Figure 8- 6 Enforcing Standards....360

Figure 8- 7 Standard Management Teams 362
Figure 8- 8 Three Types of Intellectual Property 365
Figure 8- 9 Contract Management Stages 366
Figure 8- 10 Domestic Versus International Contracts 366
Figure 8- 11 International Standards 369
Figure 8- 12 Improving International Mobility 370
Figure 8- 13 Ethical Problems and Solutions 377
Figure 8- 14 Obstacles to Ethical Decision Making: Rationalizations 378

Preface

The universe of competencies required by those in engineering management is rapidly expanding. A paradox exists in that the more new learning the engineering manager needs to acquire, the less time is available to acquire it. The *Guide to Engineering Management Body of Knowledge* is an authoritative source that provides the engineering manager with a comprehensive view of eight domains of knowledge relative to their work. Whether you are a practicing engineer, a manager or trainer of engineers, a student or an educator, you will find this user-friendly guide to be an indispensable resource.

The *Guide to Engineering Management Body of Knowledge* was produced as a collaborative effort initiated by the American Society of Mechanical Engineers (ASME) in cooperation with the American Institute of Chemical Engineering (AIChE), the American Society of Civil Engineers (ASCE), the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), the American Society of Engineering Management (ASEM) and the Society of Manufacturing Engineers (SME).

This guide is written with the needs of the reader in mind. Deliberate attention has been paid to structuring the content in such a way that the engineering manager can quickly grasp and use the concepts presented. Simplified language has been used to foster a ready understanding of the eight domains of knowledge captured in the book.

The Guide is a snapshot in time of the engineering management profession. As with all professions, the Body of Knowledge (BOK) rests with the practitioners and academics that apply and advance it. The complete BOK includes traditional practices that are widely applied and accepted, as well as innovative practices that are emerging in the profession, including published and unpublished material. As a result, the Body of Knowledge is constantly evolving.

Acknowledgements

ASME is pleased to acknowledge the volunteers who make up the Body of Knowledge, Examination, and Curriculum Advisory Committees. Their hard work, dedication, and professionalism have made possible this unified engineering management Body of Knowledge.

BOK Committee

John Bozewicz, Chair
Head, Machinery Information, Sensors and Control Systems Division, Naval Surface Warfare Center, Philadelphia PA, USA
Technical Group Leader, Engineering and Technology Management Group, ASME
B.S. in Mechanical Engineering and M.S. in Engineering Management, Drexel University (USA)

Donald Baldeosingh
CEO, Enman Services Limited, Point Lisas, TRINIDAD AND TOBAGO
B.Sc. in Electrical Engineering and M.Sc. in Electronics and Instrumentation, University of the West Indies (Trinidad and Tobago)

Nael Barakat, Ph.D.
Associate Professor of Mechanical Engineering, Grand Valley State University, Grand Rapids MI, USA
Member of the Committee on Ethical Standards and Review, ASME
Ph.D. in Mechanical Engineering, McMaster University (Canada)
M.A.Sc. in Mechanical Engineering, Concordia University (Canada)
B.Eng. in Mechanical Engineering, Kuwait University (Kuwait)

William J. Daughton, Ph.D.
Executive Director, American Society of Engineering Management
Professor and Department Chair, Department of Engineering Management and Systems Engineering, Missouri University of Science and Technology, Rolla MO, USA
Ph.D. in Physics, University of Missouri-Columbia (USA)
M.S. in Physics, South Dakota School of Mines and Technology (USA)
B.A. in Mathematics, Illinois College (USA)

Benjamin (Duke) Dow, Ph.D.
Director of Middle East Programs and Assistant Chair of Extended Studies, Department of Engineering Management and Systems Engineering, Missouri University of Science and Technology, Rolla MO, USA
M.B.A., Lynchburg College (USA)
Ph.D. in Nuclear Engineering, Purdue University (USA)
M.S. in Nuclear Engineering, University of New Mexico (USA)
B.S. in Electrical Engineering, Valparaiso University (USA)

Nicholas J. Gianaris, Ph.D.
Senior Engineering Specialist, General Dynamics Land Systems, Sterling Heights MI, USA
Ph.D. and M.S.E. in Materials Science and Engineering, Johns Hopkins University (USA)
B.S. in Metallurgical Engineering and Materials Science, Carnegie Mellon University (USA)

Caijin Huang, Ph.D.
Associate Head and Associate Professor, Department of Management Science and Engineering, Shanghai Jiao Tong University, Shanghai CHINA
Ph.D. in Management Science and Engineering, Shanghai Jiaotong University (China)
B.S. and M.S. in Mechanical Engineering, Shanghai Jiaotong University (China)

BOK Committee (cont.)

Robert Laney
Lecturer in Engineering Management, Department of Engineering Management and Systems Engineering, Missouri University of Science and Technology, Rolla MO, USA
M.S. in Accounting, University of Missouri (USA)
B.S. in Engineering Management, University of Missouri-Rolla (Now Missouri University of Science and Technology) (USA)

Stephen Long
Senior Manager, SNC-Lavalin, Inc., Houston TX, USA
B.S. in Mechanical Engineering, Texas A&M University (USA)

Darryl Mohan
Business Development Manager, First Forum International Limited, Point Lisas TRINIDAD AND TOBAGO
M.B.A., Queen's University (Canada)
B.A. in Economic Geography, University of Toronto (Canada)

Hiral Shah, Ph.D.
Assistant Professor of Mechanical and Manufacturing Engineering, St. Cloud State University, St. Cloud MN, USA
Ph.D. in Technology/Engineering Management, Eastern Michigan University (USA)
M.S. in Engineering Management, Eastern Michigan University (USA)
B.S. in Mechanical Engineering, Maharaja Sayajirao University (India)

Dawn Utley, Ph.D.
President, American Society of Engineering Management
Associate Professor of Industrial and Systems Engineering, University of Alabama at Huntsville, USA
Ph.D. in Engineering Management, University of Alabama at Huntsville (USA)
M.S. in Industrial Engineering, University of Tennessee (USA)
B.S. in Civil Engineering, Tennessee Technological University (USA)

Jerry Westbrook, Ph.D.
Executive Director Emeritus, American Society of Engineering Management
Professor Emeritus of Engineering Management, University of Alabama at Huntsville, USA
Ph.D in Industrial Engineering, Virginia Polytechnic University (USA)
M.S. in Industrial Engineering, University of Tennessee (USA)
B.S. in Electrical Engineering, Vanderbilt University (USA)

Carl Williams
Associate Professor, Department of Engineering Technology, University of Memphis, Memphis TN, USA
Ph.D. Candidate in Supply Chain Management, University of Memphis (USA)
M.S. in Industrial and Systems Engineering, University of Memphis (USA)
M.B.A. in Marketing, Memphis State University (USA)
B.S./B.S. in Industrial Engineering/Production Management, Mississippi State University (USA)

Bjong Wolf Yeigh, Ph.D.
President, State University of New York Institute of Technology, Utica NY, USA
Ph.D. in Civil Engineering and Operations Research, Princeton University (USA)
M.S. in Mechanical Engineering, Stanford University (USA)
A.B. in Engineering Science, Dartmouth College (USA)

Examination Committee

Michael Kamel, Ph.D., Chair
Senior Manager, Corporate Strategy Consulting, Deloitte & Touche LLP, Montréal CANADA
Ph.D. in Engineering Management, École Polytechnique de Montréal (Canada)
M.Sc. in Engineering Management, École Polytechnique de Montréal (Canada)
B.Eng. in Mechanical Engineering, McGill University (Montréal)

Examination Committee (cont.)

Stanley L. Cohen, Ph.D.
President, Human Systems Technology Corporation, Columbia MD, USA
Ph.D. in Psychology, The George Washington University (USA)
M.A. in Industrial Psychology, The George Washington University (USA)
B.S. in Psychology, The George Washington University (USA)

George Shinkle, Ph.D.
Principal, Direction Associates, Inc., Anderson IN, USA
Candidate for Ph.D. in Strategic Management, Purdue University (USA)
M.B.A., Ball State University (USA)
B.S. in Mechanical Engineering, Purdue University (USA)

Paul Stevenson
Vice President, McCormick Stevenson Corporation, Clearwater FL, USA
B.S. in Mechanical Engineering, University of South Florida (USA)

John R. Turney, Ph.D.
Executive Vice President, Human Systems Technology Corporation, Columbia MD, USA
Ph.D. in Psychology, Cornell University (USA)
M.S. in Industrial and Labor Relations, Cornell University (USA)
B.A. in Psychology, Princeton University (USA)

Timothy R. Weilbaker
Founder and CEO, Process Thinking LLC, New Albany IN, USA
Doctoral Fellow in Engineering Management, Eastern Michigan University (USA)
M.B.A., University of Phoenix (USA)
B.S. in Industrial/Manufacturing Technology, Eastern Michigan University (USA)
A.A.S. in Mechanical Engineering Technology, Purdue University (USA)

Curriculum Advisory Committee

Stephen V. Smith, Ph.D., Chair
Principal, Engineering Leadership Development Associates, Huntingdon Valley PA, USA
Ph.D. in Mechanical Engineering, Drexel University (USA)
B.S. and M.S. in Chemical Engineering, Drexel University (USA)

Rodney Grubb
Principal, RG^2 Associates LLC, Knoxville TN, USA
Candidate for Ph.D. in Engineering Management, University of Alabama at Huntsville (USA)
M.S. in Industrial Engineering, University of Tennessee Space Institute (USA)
B.S. in Engineering Science and Mechanics, University of Tennessee Knoxville (USA)

Wenhao Liu, Ph.D.
General Manager, Shanghai CIETRON Management Consulting Company, Shanghai, CHINA
Ph.D. in Management, Stanford University
M.S. in Computer Science, Stanford University
B.S. in Environmental Engineering, Shanghai Tongji University (China)

Bassam Samman
CEO and Founder, Collaboration Management and Control Solutions (CMCS) FZ LLC, Dubai, UNITED ARAB EMIRATES
Candidate for Ph.D. in Risk Management, Salford University (UK)
Master's in Engineering Administration, The George Washington University (USA)
Bachelor in Civil Engineering, Kuwait University (Kuwait)

Col. Timothy E. Trainor, Ph.D.
Professor and Head, Department of Systems Engineering, United States Military Academy, West Point NY, USA
Ph.D. in Industrial Engineering, North Carolina State University (USA)
M.B.A., Fuqua School of Business, Duke University (USA)
B.S. in Engineering Mechanics, United States Military Academy (USA)

Introduction

The purpose of this Guide is to answer the question: "What does it take to be an effective engineering manager?" To learn the answer, panels of practicing engineers from industry, government and academia were assembled to develop a body of knowledge based on the best practices of engineering management. Once determined, the knowledge and skills in the Body of Knowledge were reviewed and prioritized by engineering managers of all disciplines in terms of their importance and frequency of use in their practices. The result is eight domains of knowledge covering 46 knowledge areas, broken down into 210 sub-knowledge areas.

This book begins with an overview of the Body of Knowledge (BOK) and then gives detailed descriptions, application examples, diagrams, review questions and further resources for each of the eight domains. It concludes with a glossary of terms, a list of common acronyms, a summary of engineering management knowledge areas and a thorough index presented as features that lend to the user-friendly design of the guide. Footnotes appear throughout the book to provide references that will allow the reader to delve more deeply into specific topics of interest.

Purpose

The primary purpose of the Guide is to flesh out the sub-knowledge areas of the BOK and speak to what is generally recognized as best practice in each area. "Generally recognized" means that the concepts and practices presented herein are meant to provide a general overview of each topic, as opposed to an exhaustive description of each. "Best practice" means that there is general agreement by management experts that the correct application of the skills, tools, techniques and strategies described can enhance the likelihood of success in implementing each of the eight domains. This does not mean, however, that every concept presented should be applied uniformly to each aspect of engineering management. Practitioners will depend upon their professional judgment, experience and discretion to decide on the appropriateness of each practice to the task at hand.

The Guide captures many of the most commonly used current practices in the management field as opposed to addressing every topic and every detail involved with engineering management. It does, however, capture many of the most commonly used current practices in the management field. Some management concepts are so general that there is little that is directly relative to engineering management. Other management strategies may be so innovative that there is a lack of consensus as to their usefulness in an engineering environment. Yet other topics or practices do not lend themselves to being generalized across national boundaries due to their interrelatedness with their culture of origin. This guide endeavors to primarily present practices that are universally applicable rather than nationally specific.

Who will benefit from studying the *Guide*?

There are a number of applications for the information contained in this guide:

- Engineers who wishes to supplement, update or refresh their knowledge of engineering management practices will find this guide to be an indispensable resource.
- Academic institutions will find that the Guide gives students and academicians alike a realistic look at the duties and responsibilities of today's engineering managers. Incorporating this guide into standard curricula will provide timely guidance for students who aspire to lead engineering teams of the future.
- Training organizations who specialize in upskilling engineers will want to add this text to their list of suggested readings. Trainers will find that the guide enriches their current training offerings with its succinct descriptions of the real life challenges currently faced by engineering managers.
- Corporations and engineering firms of all sizes will be interested in using this guide within their organizations. The Guide is an invaluable addition to corporate libraries, corporate universities and in-house training offerings. Every engineering manager will benefit from having this book within reach to reference on a regular basis.
- Key stakeholders, customers and partners who work closely with engineering managers will garner new perspectives and insights into the roles, tasks and responsibilities of the engineering managers who assist with their success.

If you are an engineering manager who has procured a copy of this guide on loan, you will find it well worth your small investment to purchase a copy of your own. Having a copy on hand when you simply need a fast answer or want a deeper understanding of a new management concept will save you time, curtail your frustration and could even save your company from costly errors.

Overview

The *Guide* contains eight chapters. Each chapter is dedicated to a knowledge domain of the Body of Knowledge. While all chapters were thoroughly reviewed for this edition, the most extensive changes were to the chapters dedicated to Domains 3 and 7. These two chapters were significantly restructured.

Domain 1: Market Research, Assessment and Forecasting describes the processes and activities involved in conducting market research. It consists of an overview of the market analysis process and provides guidance for making recommendations and communicating the results of the study to non-marketing personnel. Environmental scanning techniques presented include *benchmarking* practices and processes, *business forecasting* methods, *risk analysis* strategies and *trend analysis* techniques.

To ensure the successful marketing of a product or service, a company must not only assess the external environment but internal capabilities as well. The steps common to conducting a *technology assessment* are described to aid the engineering manager in evaluating the technological capabilities of their competitors' technology and their own company's capabilities as well. Domain 1 concludes with a description of best practice oral and written *presentation techniques* to assist engineering managers in making a convincing presentation of study results and recommendations.

Domain 2: Strategic Planning and Change Management addresses the internal and external processes used to bring a new product or technology to market. Methods are described for planning and implementing new technologies in new global destinations. Knowledge of sources available to conduct competitive intelligence will assist engineering managers in making appropriate recommendations and crafting plans to ensure the new technology being introduced will capture the desired share of the new market.

Information about the tools and techniques used in successful system design, the impact of lifecycle engineering on system design processes and products and the tools and techniques for comparing and selecting alternative designs are detailed in this chapter. That is followed by an overview of strategic management models and tools, with an emphasis on how management strategies must adapt to the particulars of a global, service-based economy. Partnering and outsourcing strategies and relationships are also explored and financial risk management strategies and models are examined. The chapter concludes with a discussion of change management techniques and adjustment strategies used to introduce and integrate needed changes to the company's planning and business strategies.

Domain 3: Product, Service and Process Development begins by identifying the appropriate engineering disciplines involved in product development and discusses how to apply various disciplines to interpreting research findings and development results. A complete section concerning manufacturability of a product provides knowledge of pilot production and feedback processes, product feasibility planning, assembly and disassembly procedures, *Kaizan* (a.k.a. *Kaizenshiro* or *Kaizen*) and Lean production techniques.

Quality analysis techniques such as *Total Quality Management* (TQM) and *Six Sigma* are discussed and information about simulation models is provided. Techniques to design experiments such as Robust Design are examined and computer hardware and software that support manufacturability are explored. The chapter ends with the discussion of the product and service specifications involved with system design methodologies and lifecycle engineering product and process creation techniques.

Domain 4: Engineering Projects and Process Management reveals the techniques involved with establishing financial resource requirements, making financial projections, developing a budget and measuring *return on investment* for the product production project. Project management fundamentals, project management planning and control concepts, scheduling and budgeting practices and assessment of legal liabilities are all considered.

Application of project planning concepts and the utilization of project management experts are ascertained. Knowledge of work schedule breakdown techniques take into account human resource constraints and supply chain and demand constraints that pose challenges when staffing and scheduling a project. Computer hardware and software requirements that support project management functions are also discussed.

Strategies for assessing and maintaining customer satisfaction are presented and ways to adapt to changing customer service needs are considered. Industry and regulatory *standards* for quality are looked at and TQM processes are detailed. Cycle time analysis and maintenance and repair oversight considerations are addressed. The chapter concludes with a presentation of methods used to find the root cause of operational challenges and respond effectively to project problems as they arise.

Domain 5: Financial Resource Management opens with discussion of procurement and contract procedures and presents techniques for proper documentation of contracts. Information is provided about *Uniform Contract Format (UCF)* and various kinds of contracts are studied. The reading, interpretation and management of contracts is highlighted.

Identification of project funding sources and alternative funding sources is presented along with information about how to develop funding proposals and how to implement funding plans. Knowledge of budgeting and cash flow management techniques and how to interpret *balance sheets* and *income statements* is provided. Information about engineering economic analysis techniques such as Return On Investment (ROI) and *Net Present Value* (NPV) is revealed and how to interpret and apply the results of an economic analysis is examined. The chapter closes with a look at inventory control procedures and supply chain management.

Domain 6: Marketing, Sales and Communications Management describes U.S. and global marketing practices and provides insights into the development of a sales and advertising plan. Methods to reliably measure and improve customer satisfaction ratings are presented. Marketing and branding techniques are explored and followed with a discussion of how to develop and promote brands.

Product portfolio analysis is described with emphasis on how to evaluate the appropriateness of a portfolio based on competition, technology and market forces. Global trade and international operations are discussed along with important considerations to bear in mind when doing business across cultures. The chapter concludes with a look at pricing strategies, the impact of pricing on marketing strategy and ways to evaluate the appropriateness of pricing in light of competition, technology and market forces.

Domain 7: Leadership and Organizational Management examines the management styles and organizational structures most conducive to managing professionals, including engineers, whose primary labor is intellectual (as opposed to manual). Dr. Jerry Westbrook's five-element Integrated Management Model is used as the basis of this examination. The model's elements include: management systems, organization structure, people orientation, and the internal and external business environments they operate in.

After a brief, context-setting survey of the six key schools of management thought, each of the integrated model's five elements is examined in depth. The focus of each discussion is on the way that each element—alone and in concert with the other elements--can be optimized to enhance the productivity of engineers and other knowledge workers.

The domain concludes with an examination of key human resources managements concepts and practices. These include the recruitment, selection and compensation of employees, the management of a diverse workforce, techniques for conflict resolution and suggestions for the effective negotiation of labor disputes.

Domain 8: Professional Responsibility, Ethics and Legal Issues presents knowledge of topics typically covered in procedure documents. Understanding and application of regulatory requirements, *codes* and standards is covered along with methods for communicating standards to direct reports and training them to meet the standards prescribed. Information about how to monitor and enforce standards, address violations and improve adherence to standards is presented.

Intellectual property considerations such as business contracts, *patents, copyright* and *trademark* laws are explored to ensure that intellectual property is adequately protected. U.S. and international codes, standards and regulations are discussed in the context of working with international companies. The chapter comes to a close with a discussion of the professional *code of ethics* and professional liability when dealing with international engineering projects.

In its totality, the Guide offers a comprehensive view of the roles and responsibilities that an engineering manager assumes from the cradle to the grave in the engineering production process.

Summary of Engineering Management Knowledge Areas

Domain 1: Market Research, Assessment and Forecasting

1.1 Market analysis (customer base, competition)

- 1.1.1 Knowledge of basic tools and techniques
- 1.1.2 Performing a market analysis, interpreting the results, and making appropriate recommendations
- 1.1.3 Communicating results and recommendations to non-marketing personnel

1.2 Best practices and lessons learned

- 1.2.1 Knowledge of bench marking techniques and sources of information to identify best practices in other companies
- 1.2.2 Applying best practices and lessons learned to current practices in-company in order to improve functioning.

1.3 Business research and forecasting tools and techniques

- 1.3.1 Knowledge of models, methods, and techniques
- 1.3.2 Applying techniques, interpreting the results, and making appropriate recommendations
- 1.3.3 Communicating results and recommendations

1.4 Risk analysis

- 1.4.1 Knowledge of basic tools and techniques
- 1.4.2 Performing a risk analysis, interpreting the results, and making appropriate recommendations
- 1.4.3 Communicating results and recommendations

1.5 Trend analysis (economics, social, political, environmental, technology

- 1.5.1 Knowledge of basic tools and techniques
- 1.5.2 Knowledge of processes and methods of manufacturing
- 1.5.3 Performing a trend analysis, interpreting the results, and making appropriate recommendations
- 1.5.4 Communicating results and recommendations

1.6 Technology assessment practices and techniques

- 1.6.1 Knowledge of practices and techniques
- 1.6.2 Applying technology assessment practices and techniques, interpreting the results, and making appropriate recommendations
- 1.6.3 Communicating results and recommendations

1.7 Presentation Skills

- 1.7.1 Knowledge of presentation techniques including hardware and software tools
- 1.7.2 Written Communication
- 1.7.3 Oral Communication
- 1.7.4 Listening and responding to questions or disagreements

Domain 2: Strategic Planning and Change Management

2.1 Strategic destinations and planning (new technologies)

- 2.1.1 Knowledge of methods for planning & implementing new technology in new destinations on a global basis
- 2.1.2 Knowledge of sources available to obtain information on competitors
- 2.1.3 Applying methods, synthesizing information, interpreting results, and making appropriate recommendations
- 2.1.4 Using available resources to formulate action plans
- 2.1.5 Communicate recommendations and action plans

2.2 System design and life cycle engineering

- 2.2.1 Knowledge of the tools and techniques of system design including system simulation tools
- 2.2.2 Phases of a project life cycle
- 2.2.3 Applying tools and techniques to compare alternative designs and select an appropriate model

2.3 Strategic Management

- 2.3.1 The Strategic Management Model
- 2.3.2 The Portfolio Matrix
- 2.3.3 The SWOT Matrix
- 2.3.4 The Life Cycle Model
- 2.3.5 Three Generic Strategies
- 2.3.6 Porter's Model
- 2.3.7 Industry and competitor analysis
- 2.3.8 Global Competition
- 2.3.9 Global Strategy
- 2.3.10 Core Competence Strategy
- 2.3.11 Developing strategies at the Local Level

2.4 Partnering and outsourcing strategies

- 2.4.1 Knowledge of outsourcing and partnering resources
- 2.4.2 Knowledge of company business and strategic plans
- 2.4.3 Establishing outsourcing relationships
- 2.4.4 Establishing partnering relationships

2.5 Risk management strategies and techniques for new technologies

- 2.5.1 Knowledge of techniques
- 2.5.2 Performing an analysis to assess the risks of introducing new technology into various markets

2.6 Change management techniques and adjustment strategies

- 2.6.1 Knowledge of change process dynamics
- 2.6.2 Knowledge of factors contributing to resistance to change
- 2.6.3 Implementing change effectively in a group or team

Domain 3: Product, Service and Process Development

3.1 Engineering disciplines

- 3.1.1 Knowledge of appropriate engineering disciplines
- 3.1.2 Applying engineering disciplines to interpret research and development results
- 3.1.3 Applying engineering technologies to develop products and processes or evaluate alternatives

3.2 Manufacturability

- 3.2.1 Knowledge of pilot production and feedback process
- 3.2.2 Knowledge of product feasibility, planning, and development tools
- 3.2.3 Knowledge of design for manufacturing and assembly/disassembly procedures
- 3.2.4 Knowledge of Kaizan and Lean production techniques
- 3.2.5 Knowledge of quality analysis techniques such as TQM and Six Sigma
- 3.2.6 Knowledge of simulation models and applications
- 3.2.7 Knowledge of Computer-Driven Software Systems That Can Translate Customer Information Into Product Design Requirements
- 3.2.8 Knowledge of techniques to design experiments
- 3.2.9 Applying the tools and techniques to evaluate the manufacturability of one product or alternative products considering technical and practicality factors

3.3 System design methodology and life cycle engineering product/process creation (product or service specifications)

- 3.3.1 Knowledge of integrated product design and development methods
- 3.3.2 Knowledge of life cycle engineering analysis
- 3.3.3 Knowledge of factors that influence product creation such as design for environment, design for maintenance, design for re-usability, design for service, design for disposal, and design for life cycle analysis (design for “X”)
- 3.3.4 Knowledge of cost analysis techniques
- 3.3.5 Knowledge of simulation models
- 3.3.6 Knowledge of web-based product design tools
- 3.3.7 Applying techniques to design products, services, and processes from a total system and life cycle engineering perspective

Domain 4: Engineering Projects and Process Management

4.1 Project management techniques

- 4.1.1 Knowledge of project management fundamentals (e.g. work breakdown structure, task and schedule development) and strategies (e.g. Earned Value Analysis)
- 4.1.2 Knowledge of project management planning and control concepts
- 4.1.3 Knowledge of techniques to determine scope, schedule, and budget
- 4.1.4 Knowledge of techniques for assessing project risk
- 4.1.5 Knowledge of techniques for project planning
- 4.1.6 Knowledge of project management resources

4.2 Scheduling techniques

4.2.1 Knowledge of work schedule breakdown techniques to schedule work taking into account human resource constraints, supply chain constraints, and demand constraints

4.2.2 Knowledge of techniques for work scheduling

4.3 Strategies for maintaining customer service and satisfaction

4.3.1 Knowledge of techniques for obtaining customer feedback

4.3.2 Knowledge techniques for adapting work to meet changing customer needs in a reliable manner

4.4 Total Quality Management (TQM); continuous process improvement

4.4.1 Knowledge of industry and regulatory standards for quality (e.g., ISO, ANSI, etc)

4.4.2 Knowledge of quality process management techniques (other than TQM)

4.5 Project and Process Tools

4.5.1 Knowledge of root cause analysis techniques

4.5.2 Responding to identified problems

Domain 5: Financial Resource Management

5.1 Procurement and contract procedures; contract management

5.1.1 Knowledge of contract procedures and regulations

5.1.2 Knowledge of techniques for proper documentation of contracts

5.1.3 Knowledge of Uniform Contract Format (UCF)

5.1.4 Knowledge of various contract types

5.1.5 Overseeing the preparation of contracts

5.1.6 Reading and interpreting contracts

5.1.7 Managing contracts

5.1.8 Interacting with contract personnel

5.2 Funding sources

5.2.1 Identifying available and alternative funding sources

5.2.2 Knowledge of financial constraints

5.2.3 Developing funding proposals and implementing funding plans

5.3 Financial accounting and budgeting procedures; balance sheets; cash flow

5.3.1 Knowledge of budgeting techniques

5.3.2 Knowledge of alternative budgeting procedures

5.3.3 Knowledge of cash flow techniques and requirements

5.3.4 Knowledge of business plan fundamentals and key components

5.3.5 Evaluating the contents of business plans

5.3.6 Interpreting balance sheets, income statements (P&Ls)

5.4 Engineering economic analysis techniques

- 5.4.1 Knowledge of engineering economic analysis techniques such as NPV
- 5.4.2 Interpreting and applying the results of engineering economic analyses
- 5.4.3 Calculating economic equivalence, purchasing power of money, and estimation of costs
- 5.4.4 Audit processes, practices, key policies/regulations (SOX),

5.5 Capital Budget and Resource Planning

- 5.5.1 Knowledge and techniques to establish financial resource requirements including budget processes and financial projections
- 5.5.2 Knowledge of techniques to establish capital resource requirements (e.g., equipment facilities and equity)
- 5.5.3 Knowledge of techniques for measuring return on investment

5.6 Inventory control procedures and supply chain management

- 5.6.1 Knowledge of supply and usage procedures such as JIT
- 5.6.2 Knowledge of inventory control software, ecommerce
- 5.6.3 Monitoring inventory and ensuring sufficient supplies

Domain 6: Marketing, Sales and Communications Management

6.1 Sales and advertising practices

- 6.1.1 Knowledge of U.S. practices
- 6.1.2 Knowledge of global practices
- 6.1.3 Developing and implementing a sales and advertising plan

6.2 Customer satisfaction strategies

- 6.2.1 Knowledge of techniques to obtain reliable measures of customer satisfaction
- 6.2.2 Analyzing current levels of customer satisfaction and recommending strategies for improvement

6.3 Marketing and branding techniques

- 6.3.1 Knowledge of techniques
- 6.3.2 Applying the techniques, interpreting the results, and making appropriate recommendations
- 6.3.3 Communicating recommendations to non-marketing personnel
- 6.3.4 Developing and promoting brands

6.4 Product portfolio analysis

- 6.4.1 Analyzing a current product portfolio
- 6.4.2 Evaluating the appropriateness of the portfolio based upon competition, technology and market forces, and making recommendations

6.5 Global trade and international operations

- 6.5.1 Knowledge of global trade and international operations
- 6.5.2 Knowledge of cross-cultural management differences
- 6.5.3 Interacting with managers in other cultures

6.6 Pricing strategies

- 6.6.1 Knowledge of current pricing strategy,
- 6.6.2 Evaluating the appropriateness of the pricing to the competition, technology, and market forces
- 6.6.3 Communicating the impact of pricing on marketing strategy

Domain 7: Leadership and Organizational Management

7.1 Schools of Management Thought

- 7.1.1 Management Function School
- 7.1.2 Behavioral School
- 7.1.3 Mathematical School

7.2 Managing and Motivating Knowledge Workers

- 7.2.1 The Impact of Assumptions
- 7.2.2 Identifying and Meeting Employee Needs
- 7.2.3 Motivator-Hygiene Concept
- 7.2.4 Achievement-Affiliated Orientations
- 7.2.5 Management Styles and Group Processes
- 7.2.6 Defined Management Systems
- 7.2.7 Managerial Grid Approach

7.3 Organization Structure

- 7.3.1 Organic vs. Mechanistic Structures
- 7.3.2 Typical Structure Types
- 7.3.3 Models of Structures

7.4 Management Systems and Systems Thinking

- 7.4.1 Systems Thinking
- 7.4.2 The Five Disciplines
- 7.4.3 Openness and Localness
- 7.4.4 Archetypes
- 7.4.5 Case Studies and Problem Solving
- 7.4.6 Identifying Management Systems Applicable to Tech-Driven Organizations

7.5 Leadership

- 7.5.1 Management vs. Leadership
- 7.5.2 The Covey Approach
- 7.5.3 The Kouzes and Posner Transformational Leadership Approach
- 7.5.4 Proactive Leadership
- 7.5.5 Leadership Succession Planning

7.6 Human Resources Management

- 7.6.1 Recruitment, selection, and compensation practices
- 7.6.2 Managing a diverse workforce
- 7.6.3 Labor Relations

Domain 8: Professional Responsibility, Ethics and Legal Issues

8.1 Professionalism

- 8.1.1 Continuous Professional Improvement
- 8.1.2 Certification, Accreditation, Licensure (highlight differences across cultures)
- 8.1.3 Ethical vs. Legal

8.2 Compliance Procedures

- 8.2.1 Knowledge of topics typically covered in procedure documents
- 8.2.2 Interpreting and applying procedures in engineering projects

8.3 Regulatory Requirements, Codes, and Standards

- 8.3.1 Knowledge of regulatory and industry standards involving safety and the environment
- 8.3.2 Communicating standards and training direct reports
- 8.3.3 Monitoring and enforcing standards
- 8.3.4 Addressing violations
- 8.3.5 Improving adherence to standards

8.4 Business Contract, Patent, Copyright, and Trademark Laws and Intellectual Property

- 8.4.1 Knowledge of contract, copyright, trademark laws, patents
- 8.4.2 Interpreting and applying laws within the context of contract and project requirements
- 8.4.3 Ensuring that intellectual property is adequately protected

8.5 U.S. and international Codes, Standards, and Regulations

- 8.5.1 Knowledge of international standards, codes, and regulations
- 8.5.2 Knowledge of U.S. standards, codes, and regulations for working with international companies (non-U.S.)
- 8.5.3 Applying standards to international engineering projects

8.6 Professional Codes of Ethics; Professional Liability

- 8.6.1 Knowledge of professional ethical standards and corporate codes
- 8.6.2 Applying and enforcing standards when dealing with ethical or professional liability issues involving direct reports
- 8.6.3 Applying and enforcing standards when dealing with ethical or professional liability issues in international engineering projects

Engineering Management Certification International Body of Knowledge

Domain 1: Market Research, Assessment and Forecasting

Domain 2: Strategic Planning and Change Management

Domain 3: Product, Service and Process Development

Domain 4: Engineering Projects and Process Management

Domain 5: Financial Resource Management

Domain 6: Marketing, Sales and Communications Management

Domain 7: Leadership and Organizational Management

Domain 8: Professional Responsibility, Ethics and Legal Issues

Domain 1: Market Research, Assessment and Forecasting

Domain Champion: Darryl Mohan

1.1 Market analysis (customer base, competition)

- 1.1.1 Knowledge of basic tools and techniques
- 1.1.2 Performing a market analysis, interpreting the results, and making appropriate recommendations
- 1.1.3 Communicating results and recommendations to non-marketing personnel

1.2 Best practices and lessons learned

- 1.2.1 Knowledge of bench marking techniques and sources of information to identify best practices in other companies
- 1.2.2 Applying best practices and lessons learned to current practices in-company in order to improve functioning.

1.3 Business research and forecasting tools and techniques

- 1.3.1 Knowledge of models, methods, and techniques
- 1.3.2 Applying techniques, interpreting the results, and making appropriate recommendations
- 1.3.3 Communicating results and recommendations

1.4 Risk analysis

- 1.4.1 Knowledge of basic tools and techniques
- 1.4.2 Performing a risk analysis, interpreting the results, and making appropriate recommendations
- 1.4.3 Communicating results and recommendations

1.5 Trend analysis (economics, social, political, environmental, technology

- 1.5.1 Knowledge of basic tools and techniques
- 1.5.2 Knowledge of processes and methods of manufacturing
- 1.5.3 Performing a trend analysis, interpreting the results, and making appropriate recommendations
- 1.5.4 Communicating results and recommendations

1.6 Technology assessment practices and techniques

- 1.6.1 Knowledge of practices and techniques
- 1.6.2 Applying technology assessment practices and techniques, interpreting the results, and making appropriate recommendations
- 1.6.3 Communicating results and recommendations

1.7 Presentation Skills

- 1.7.1 Knowledge of presentation techniques including hardware and software tools
- 1.7.2 Written Communication
- 1.7.3 Oral Communication
- 1.7.4 Listening and responding to questions or disagreements

Domain 1: Market Research, Assessment and Forecasting

Key Words and Concepts

Benchmarking	The process of improving performance by continuously identifying, understanding, and adapting the best practices and processes found inside and outside the organization.
Business Forecasting	A means of measuring economic conditions using statistical models to predict the potential market attractiveness and the organization's competition position factors a future time
Market Analysis	The collection of information used to identify and define market opportunities and problems, and to generate, refine and evaluate market option
Market Analysis Report	A formal document used to record the findings of a market analysis, formulate recommendations and share findings with key stakeholders
Presentation Techniques	Oral and written communications methods to assist in a focused expression of ideas, recommendations and findings used to inform and influence the thinking of others
Risk Analysis	A formal framework for identifying how avoid disruption of an organization's marketing plans. Risk equals the probability of an event multiplied by the cost of that event.
Risk Register	A progressive document used over time that contains the outcomes of all risk management processes throughout the lifecycle of the marketing project
Trend Analysis	A process that uses historical data to examine what has happened in an organization's past to assist in predicting what might occur in the future
Technology Assessment	An assessment process used to determine the capabilities of any given technology, including its specifications and performance, and applicability to a planned project

1.1 Market Analysis

The ultimate success of any commercial organization depends upon its ability to determine the its customers' needs. Even before product and service offerings are designed, a seller must learn about its customers and competitors. Sellers obtain this information through a variety of market research methods, environmental scanning efforts and competitive intelligence activities. In order to achieve meaningful results, engineering managers need to possess knowledge of the basic tools and techniques required to gather and analyze this customer-driven data.

1.1.1 Knowledge of Basic Tools and Techniques

Becoming masterful in market analysis is a priority for the savvy engineering manager. To compete today, product viability must be assessed before product development begins.

Specifically, *market analysis* is the identification and assessment of the target market, the competition and the demand for a product or service. Market analysis is a dynamic process and there is no one single or most effective methodology to use. Conducting market research is both an art and a science and generally involves a team of associates who bring together different mindsets, resources, skills and experiences to the research and analysis process.

Market analysis is conducted before committing to any business strategy and may be a relatively simple or highly sophisticated process depending upon the tools and techniques used to gather, analyze and interpret data and report findings.

The American Management Association defines marketing research as: "the function which links the consumer, customer and public to the marketer through information — information used to identify and define marketing opportunities and problems; generate, refine, and evaluate marketing actions; monitor marketing performance; and improve understanding of marketing as a process."[1]

The steps comprising market analysis can be fraught with the potential for error (Figure 1-1). Decision makers and researchers must work closely together when agreeing to the objectives of the research and developing the questions to be answered by the study.

[1] American Management Association, "Fundamentals of Marketing." Available at http://www.amanet.org/seminars/category.cfm?cat=212&org=Sem.

Steps	Potential Errors
1. Formulate objective(s)	Management identifies the wrong problem, poorly defines problems or misses potential opportunities.
2. Determine information needs and data sources	Management fails to identify the specific information needed for decision making or the researcher uses the wrong source.
3. Research design	Ambiguous questions or poor experimental designs result in invalid responses.
4. Select sample and size	Sample procedures result in selection of a biased sample.
5. Collect data	Errors are caused by non-respondents, by the interviewer, or by the nature of the interviewer/respondent interaction.
6. Tabulate, analyze and report data	Errors occur while transforming raw data from questionnaires into research findings. Data is reported using terminology not understood by non-marketing personnel.

Figure 1- 1 Steps in the Marketing Research Process and Potential Sources of Error[2]

1.1.2 Performing Market Analysis, Interpreting the Results and Making Appropriate Recommendations

The following steps comprise the market analysis process.

.1 Describe the Objective(s)

Begin the market analysis by specifically stating desired results. Consider potential obstacles and marketplace opportunities.

Questions to ask:

- Is the goal too narrow for our focus (e.g., a new product or service) or is it too broad (e.g., opens up new markets for an existing product or refines an existing product for new markets)?
- What has been done in the recent past that was effective? By your company? By competitors?
- What is your relationship with your target market? What improvements can be made?
- What differentiates your company (and its product or service) from the competition?

[2] The Edinburgh Business School Graduate School of Business, *Heriot Watt University Marketing Course,* 1.1 ed., Pitman Publishing, 1996.

- Who are your customers?
- What do your customers need and/or want?

.2 Determine Information Needs and Data Sources

Once the objectives have been described, begin an informal survey using information that is already available. Collect company data on existing and emerging competitors. Contact knowledgeable individuals within your organization, informally poll key customers, collect information and insights from people informed about your industry and product, consult trade organizations and publications, and explore data sources on the Internet. Frequently the information gathered at this early stage will lead to a redefinition of the objectives.

.3 Research Design — Focused, Formal, In-Depth Data Collection

After completing your informal survey and clearly defining your research objectives, determine how to best collect the data necessary to complete your market analysis. Your formal research design is likely to be more detailed and extensive than the initial informal research activities and should be very targeted to your market analysis goal(s). Take care in data collection because using a faulty data collection method leads to inaccurate results.

Experts agree that maintaining a balance of qualitative and quantitative research data is vital to the success of the research project. Figure 1-2 provides examples of both qualitative and quantitative data collection methods:

Quantitative	Qualitative
• Surveys • Questionnaires • Experiments	• Behavioral interviews and observations • Observation • In-depth interview • Experiments • Focus groups

Figure 1- 2 Examples of Quantitative and Qualitative Primary Research Methods

Quantitative data may involve statistical analysis of the number of individuals who have purchased an item in the past two years or the number of respondents to a survey who indicated that they were interested in a particular product motivation. For quantitative data to be useful, it must include a representative sample of the target market, and the researcher must be careful to ensure that data collected matches the objective and what is being measured. Quantitative data can be difficult or costly to collect but is needed to provide a quasi-objective and measurable means of understanding the target market.

Qualitative research is inherently subjective and is designed to reveal customer attitudes, beliefs and preferences. Although the data yield supplied by qualitative research methods may appear initially to be cumbersome and overwhelming, the information to be garnered is

essential as a means of predicting customer behavior. Qualitative research consists primarily of the use of open-ended questions directed at customers and consumers in group or individual interviews.

Your research plan should also include the use of secondary research sources. Secondary sources include:

- Census data
- Government records
- Company records
- Various trade and industry sources
- Case studies
- Archival research

Secondary research data has already been collected by other sources and is often compiled for other purposes. Nevertheless, there is often useful information that can be derived from these external sources. Associations are a tremendous resource of industry-specific data. There are innumerable sources of information available through the Internet including online journals, databases and research organizations. Considerations such as cost, time, objectivity and ability will dictate whether data collection is best done by internal staff or outside consultants.

Note: Generally, the collection of primary data is expensive, while the gathering of secondary data may be of little or no cost at all.

.4 Select Sample and Size

Take a representative sampling of the target market to be sure to collect data from an appropriate range and number of sources. This will ensure that the data is reasonably representative of the potential customer base. Survey across cultural lines, socio-economic strata, industry sectors, or national boundaries. Be certain also to select a sample size that is small enough to be manageable, yet large enough to yield useful information from both over-represented and underrepresented populations.

Survey design is the crux of the research and is often best left to professional marketers and statisticians; however, if engineers are to be trained on this, they must have a knowledge of sampling methods, sampling instruments and how to determine sample size (which is a balance between acceptable confidence range and cost). Refer to a statistics textbooks for further instruction on survey design.

.5 Collect Data — Ensure Validity

Stay focused on the objective of the survey and be certain to measure what you intend to be measuring. Be on the alert for skewed data that appears to be a mismatch with the bulk of the information gathered. Is one interviewer biasing focus group outcomes? Are certain geographical areas yielding higher returns of mail-in surveys than others? These variances can give important insights into customer behavior or can be sources of invalid outcomes due to faulty data collection methods.

Double-check all data received from outside sources. Never assume that a government report, external research firm, or pollster has conducted valid research. Check the facts. Examine sample size and characteristics. Search for unexplained variances from past research outcomes. Compare the results from several sources before drawing conclusions.

.6 Tabulate, Analyze, and Report Data

Once data has been collected, assess its significance. Do this individually or as part of group. Avoid fallacies of logic, misinterpretations, and bias by making sure that conclusions drawn are supported by the data. To do this, use a information gathering technique such as "SWOT" or "PEST" (Figure 1-3) can be used to examine the data and expand the breadth of the risks being considered.[3]

SWOT
Strenths
Weasknesses
Opportunities
Threats

PEST
Political
Economic
Social
Technological

Figure 1- 3 SWOT and PEST Models of Data Analysis[4]

The process of market analysis concludes with a report detailing research findings and recommendations (see Figure 1-4). The structure of the report is similar to other engineering reports, although for market analysis reports, it is key to distinguish the recommendations in a section separate from the findings. In this way, key recommendations will be readily accessible to anyone reading the report.

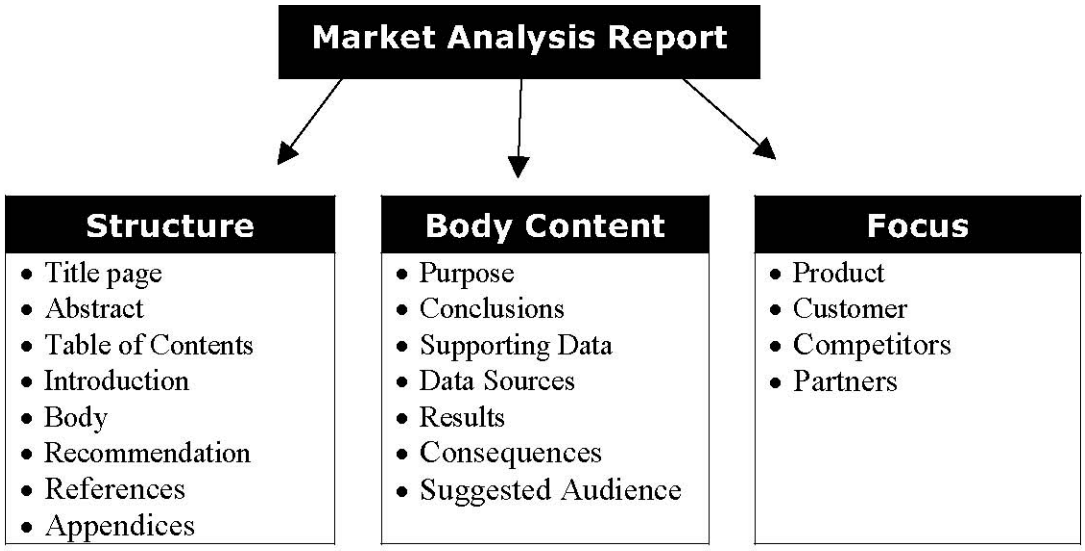

Figure 1- 4 Structure, Content and Focus of a Market Analysis Report

[3] For a discussion of SWOT in the context of strategic management, see Section 2.3.2 within Domain 2.
[4] John Middleton, *The Ultimate Strategy Library: The 50 Most Influential Strategic Ideas of All Time*, Capstone Publishing Ltd., 2003

.7 Market Analysis Report Content

It helps to clearly delineate content in the body or the report in sequential sections.

Purpose: Describe the purpose of the research and research objectives. Explain the most important feature of the research. Discuss the background of the project.

Conclusions: List all conclusions reached as a result of doing the analysis.

Supporting data: Support the conclusions by referencing research findings.

Data sources: List research contributors and describe contributions made by each. List works by other researchers used in the study. Describe ways in which research proves or disproves other researchers' work.

Results: Describe what you expected to find before beginning research. How did the project change over time? How did results differ from expectations? Describe the results. How were results checked? Represent the results using text, tables, figures, charts and graphs.

Consequences: Describe the consequences of the research. What does it mean for the subject? How will it affect future research on this subject?

Suggested audience: Describe the ideal audience for the report. Who would be most impacted by the research? Who would best understand the consequences of the research? Who needs to see the research to make marketing and design decisions? Is confidentiality an important consideration when releasing findings?

The Focus box in Figure 1-4 refers to those who will be impacted by the decision to send, or not send, a product to market. Discuss the product under consideration by listing its features and benefits.

Describe the potential customer for the product. Is the customer business-to-consumer (B2C) and/or business-to-business (B2B)?

- B2C: Considerations include demographic, geographic (including population shifts) and psychographic information.
- B2B: Considerations include the type of industry, size of each company, company culture, company's buying behavior, centralized or decentralized purchasing, and geographic location.

Describe customer needs as indicated by the research. Outline why customers buy this product. What benefits will customers derive from the product? Identify why customers buy from the company. Consider issues of price, features and benefits, distribution channels, service, brand, and image. Review how long customers researched have been purchasing from the company.

Describe the competition. Explore how the competition has changed. Is it stronger or weaker than in the past? Are you now dealing with different competitors than previously? Uncover how the competition differs (pricing, distribution channels, product features, promotion, size, geographical location(s) and number of locations) from your company. Describe what the competition is doing that is similar. Detail how the competition impacts the company product(s). Determine which competitors fall into the categories of leaders, challengers, and followers. Describe each competitor's market share.

Assess channel partners. Describe how the product is distributed. Determine what channel partners do for the company. Describe benefits channel partners offer to customers. Determine whether better channel partners are available to market the product under consideration.[5]

1.1.3 Communicating Results and Recommendations to Non-Marketing Personnel

There are a number of media you can use to communicate market analysis results to non-marketing personnel. Your company website, newsletters, information sheets, technical reports, a slideshow or video, and live presentations are the most popular methods to publicize findings. A communication plan is essential to ensure that the right information gets to the right people at the right time.

A communication plan identifies who will be interested in the research findings and how much you intend to communicate with them. Begin by identifying the target audience and assessing the most effective way to reach them. Base decisions on which communication medium will be most attention-getting, clear, concise, expedient, and useful to the target audience. Once a medium has been selected, use the following guidelines for presenting information.

- Simplify the language so that readers or listeners without backgrounds in research or marketing can readily understand the report or presentation contents.
- Create simple materials that readers can easily interpret.
- Use inviting graphics in materials intended for non-marketing audiences.
- Make certain the report or presentation is targeted to listener or reader needs. Design engineers will be impacted by the research differently than supply chain experts. Customize each presentation to the focus, concerns, tasks, and functions of audience members.

1.2 Best Practices and Lessons Learned

The results of marketing analysis are only one indication of whether a potential product will find its niche in the marketplace. The question now becomes, “Can we produce and market this product using traditional thinking and performance methods?” Often the answer is no. Then the question becomes, “What do we need to learn as an organization to be more competitive in the market?” The answer often lies in making a closer study of competing organizations.

1.2.1 Knowledge of Benchmarking Techniques and Sources of Information to Identify Best Practices in Other Companies

Benchmarking is the process of improving performance by comparing the cost, cycle time, productivity, or quality of a specific process or method to another that is widely considered to be an industry standard or best practices. This approach to process improvement is so effective because it is based on actual practices, not theory.

[5] For further information on channel partners, see any of the Kinichi Ohmae articles listed in the *For Reference* section at the end of this domain.

Studying best practices provides the greatest opportunity for gaining a strategic, operational and financial advantage. While benchmarking readily integrates with strategic initiatives such as continuous improvement, reengineering and total quality management (TQM), it is a discrete process that delivers value to the organization on its own.

The benchmarking process (Figure 1-5 below) varies greatly across industries and nations. Some anchor the effort to performance standards, while others begin the process by defining goals. For the purpose of market research, anchoring to processes will provide the engineering manager a comparative method for improving market share, distribution, sales, and budgetary considerations with an eye toward best practices in each area.

The Benchmarking Process

1) Select a process to benchmark
2) Determine the project's scope
3) Choose relevant measurement
4) Study performance boosting best practices
5) Judge appropriateness and adopt practices
6) Identify cultural issues and other implementation factors
7) Plan and implement changes
8) Measure results and analyze benefits

Figure 1- 5 The Benchmarking Process[6]

.1 Select a Process to Benchmark

Selection of a process depends upon what the organization needs to learn in order to better measure and improve internal practices. If marketing analysis shows that the chief competitor is able to bring a product to market faster than your company because of inefficiencies in your product development process, then product modification processes become your focus.

.2 Determine the Project's Scope

Clearly define the scope of your project. The product development process, for example, encompasses a number of smaller sub-processes. To determine the scope of your project, you should first determine which of those sub-processes negatively impact development time. If, after detailed study, you find that development is slowed at the point where products are modified for foreign market requirements, then this modification process is the scope of your project.

.3 Choose a Relevant Measure

Keeping in mind that searching out best practice options is the goal, investigate competitors to isolate the measures they use to keep their product modification process within acceptable timelines. Then apply these measures to your company's existing process.

[6] "Benchmarking: Leveraging Best Practice Strategies." APQC White Paper for Senior Management, APQC, 1999

.4 Study Performance-Boosting Processes

Pinpoint the ways in which your competitors excel when faced with challenges. For example, how does your competitor compensate when changing government regulations delay product modifications? Is there a protocol they use to deal with this sort of unexpected setback?

.5 Judge Appropriateness and Apply Practices

Given that your competitor's organization differs from yours in myriad ways, not all practices relevant to their success can be efficiently transplanted into your operation. Judge the relevance of the competitor's methodologies. It may be necessary to make adjustments to their strategies prior to implementing them at your company.

.6 Identify Cultural Issues and Other Implementation Factors

The corporate culture and/or geographic location of the company you are benchmarking against is likely different from yours. As a result, its management practices, division of labor, size, and accepted protocols may differ greatly. Be sure to examine whether the benchmarked practices will be accepted within your firm, and if they can be implemented as intended given your organizational structure, size and culture.

.7 Plan and Implement Changes

After refining the best practices discovered during the benchmarking process and ensuring a good fit with your organization, implement the new processes and measure their effectiveness in meeting your organization's goals.

1.2.2 Applying Best Practices and Lessons Learned to Improve Functioning

Adaptation of "best ideas" is where organizations gain their competitive advantage, and benchmarking is where many of those ideas originate. It is not sufficient to simply access and copy a competitor's strategies. To make a business case for recommended changes, the return on investment (ROI) for business restructuring must justify the change.

When analyzing the findings provided by a benchmarking study, the primary question to ask is, "How can what we learned be applied in our organization to build our capacity, capitalize on our strengths, exploit our opportunities, and overcome our obstacles?" Benchmarking is more likely to generate paybacks when it is driven by strategic objectives. Look to the organization's strategic plan to find out where the company intends to go. Look to the findings of the benchmarking project to inspire thoughts about how to get there.[7]

[7] For more information on strategy, refer to Domain 7 or the Michael Porter work cited in the *For Reference* section at the end of this domain.

1.3 Business Research and Forecasting Tools and Techniques

Strategic planning must take into account a number of variables, including economic and environmental conditions. Recessionary trends, for example, may impact sales figures if strategic planners have failed to project for such eventualities. Making accurate predictions regarding future market conditions is done through a process known as business forecasting.

1.3.1 Knowledge of Forecasting Models, Methods, and Techniques

Formal business forecasting is done using statistical models and "econometrics" which literally means "measuring the economy." The most reliable and common statistical methods used in business today are regression analysis, smoothing, decomposition, and Box-Jenkins (see also Section 1.5.1).

Forecasting, especially economic forecasting, consists of the scientific use of statistics combined with selection of what to measure and what formula or model to use, and then deciding which explanatory variables will provide the most accurate forecast when the statistics are plugged into the selected formula.

Although business forecasting can be done by an individual, a cross-departmental alliance of engineering managers using a structured discussion methodology such as a Delphi Technique (see Section 1.4.1) will likely produce a more comprehensive study of economic trends, as well as a more accurate prediction of how those trends will impact your organization's future profitability, productivity and performance.

A wide variety of forecasting software is available, including spreadsheet applications and statistical packages. Enterprise resource planning (ERP) software also contains forecasting modules. When selecting the software, it is important to consider what it is designed to measure. Some packages focus on sales and marketing forecasts, while others are specific to supply chain management.

Statistical forecasting predicts the value of one dependent variable by measuring its relationships with two or more other independent variables. For example, sales (the dependent variable) can be estimated based on age and gender (independent variables). A different forecast is derived if sales (the dependent variable) are estimated based on amount spent on advertising and the size of sales staff (independent variables).

1.3.2 Applying Forecasting Techniques, Interpreting Results, and Making Appropriate Recommendations

Steps in Forecasting
1. Identify the dependent variable — the variable to predict. Is the goal to forecast your company's sales for next year or the industry's sales trends for the next ten years?
2. Identify the independent variables — those factors believed to have the greatest influence on the dependent variable. Such factors might include, for example, economic conditions, downsizing of the sales force, or introduction of a new product.
3. Select the model (statistical technique) to use. For example, if regression analysis is selected, it also needs to be determined whether a logic regression or a log linear model based on the characteristics of the data to be supplied will be used.
4. Do the calculations (or plug the data into the appropriate forecasting software).
5. Interpret the outcome, usually presented as a model (formula) and represented in the form of a graph.

Figure 1- 6 Steps in Forecasting

In engineering circles, business decisions are made using net present value (NPV) and rate of return on investment (ROI) in order to assess the accuracy of business forecasts. The data generated by forecasting depends upon both historical data and statistical manipulation. Because of this, when using cost/parameter relationships, remember: (1) the uncertainty inherent in the extrapolation of statistics, and (2) whether the indicated relationship is logically sound and reasonable.

Forecasting of any type only creates predictions. It is much like listening to a weather report. Sometimes the report is exactly on target, and other times the sun shines when the forecaster has predicted rain. In business forecasting, statistical results may reveal that, based on a company's history of success with one product line, and forecasted economic indicators, expanding or enhancing a product line is a wise decision. Two weeks later, a catastrophic event may slow or even halt the predicted economic growth.

Many companies choose to run a number of independent projections before making a decision to move ahead. Often, both in-house experts and external consultants are employed to examine identical historical data using different statistical methods. Alternatively, a sole forecaster may manipulate a number of differing data sets to produce comparative results. When interpreting findings and formulating recommendations based on a forecast, a number of reasonable options may exist. Engineering managers will want to ask:

- If we move ahead using the predictive findings will the NPV and ROI hold in the face of faulty predictions or unforeseen circumstances?
- What risks are attached to making an investment decision now based on these projections?
- What are the best case and worst case scenarios that could play out as the result of accepting and acting upon forecasted findings?

- Does the historical data used in formulating the forecast have ongoing relevance to future situations?
- Was all relevant data available and included in making the forecast?

Before making recommendations based on forecasted information, engineering managers are wise to conduct an ROI analysis using the same suppositions used in the forecast. To do this, the manager should assemble a group of five to seven people with differing backgrounds and perspectives to consider the issues. During the meeting, adhere to the following guidelines:

- State the issue to be addressed.
- Ask each person to complete an ROI worksheet independently (see Figure 1-7).
- Tabulate the results by adding the points assigned to each item under consideration and record them on the ROI Summary.
- Total the values in each row to find which strategies might best optimize return on investment.
- Weigh outcomes during a discussion with the assembled group.

Sample ROI Worksheet	High Sales	Short Time	Low Cost	Total
Issue: What are our best long term revenue generation strategies?				
Item				
Introduce a low-end widget	2	2	1	5
Recruit new channel members	2	1	2	5
Increase advertising	2	3	1	6
Decrease sale force	1	2	1	4
Expand into foreign markets	3	1	1	5
Raise prices	2	3	3	8

ROI Summary	Joe	Sue	Bob	Total
Issue: What are our best long term revenue generation strategies?				
Item				
Introduce a low-end widget	5	6	7	18
Recruit new channel members	5	5	8	18
Increase advertising	6	4	5	15
Decrease sale force	4	6	5	15
Expand into foreign markets	5	3	6	14
Raise prices	8	4	6	18

Figure 1- 7 ROI Worksheet and Worksheet Summary[8]

1.3.3 Communicating Results and Recommendations

Using the same reporting format as described in Figure 1-4, "Structure, Content and Focus of a Market Analysis Report," document the results of the forecast and decide how to best

[8] Gary Harpst, *Six Disciplines for Excellence.* Six Disciplines Leadership Center, Ohio, 2004.

represent your recommendations. Oral presentations, slideshows, newsletters, or thorough use of the company's Intranet are all viable options for communicating outcomes and recommendations. Include information about the ROI summary and the rationale used to reach each recommendation.

1.4 Risk Analysis

The analysis of risk is viewed as a field in itself, and the demand for an orderly and formal treatment of risk is great. The process of identifying and reducing potential losses related to bringing a new product or service to market is, in itself, risky. Issues of time, cost, scope, and quality are considered when planning to bring a product to market. Timing is critical when introducing a new, refined, or enhanced product.

What could be worse than introducing a product a week after a leading competitor premiers a similar item? It could be worse if the company's product quality was inferior to the competitor's. Shifting government regulation could narrow the market available to the product. A design flaw could render the product unsafe for use by the customer. The product may be lacking the features required to generate sales. Customer whims could shift, leaving your product without a consumer base.

Risk identification is seldom a straightforward process. Regardless of how complete and thorough market research is, there are both visible and invisible risks to assess throughout the marketing project. Alternatively, risks can be positive in nature. The projections of product sales may have underestimated product demand, and now customer demand is higher than predicted.

1.4.1 Knowledge of Basic Tools and Techniques of Risk Analysis

Six steps comprise the risk identification process. All steps involve the use of a cross-departmental team often referred to as the risk analysis team.

.1 Risk Identification

1. **Review documentation:** Assemble the team to review all documentation generated by the marketing analysis effort. Marketing research, benchmarking data, and forecasting projections must be reviewed on a regular basis to check for accuracy, completeness, and ongoing applicability as the marketing process progresses.
2. **Conduct a SWOT:** Involve the documentation review team in assessing the strengths, weaknesses, opportunities, and threats (SWOT) inherent to the marketing plan. Differing perspectives can unearth risks that marketing personnel may have missed.
3. **Brainstorming:** Through the use of a structured, facilitated brainstorming session, identify potential risks and categorize them according to their probability of occurrence. "High," "moderate," and "low" categories can be used to prioritize risks so that the engineering managers know what to address first.
4. **Interviewing:** The team interviews other members of the organization who have worked on similar past projects to gain insights about how risks were identified and addressed.
5. **Root cause identification:** This is an inquiry into the essential causes of the risks that have surfaced after conducting the first four steps in this process. A simple method of

root cause identification is to ask the question, "Why?" seven times, testing each response to the question with an additional, "Why?" After seven rounds, teams have usually uncovered the root cause of the risk.

6. **Delphi Technique:** At this point in the risk identification process, the team will likely find some disagreement among themselves about what is viewed as risky and how to prioritize risks. The Delphi is an anonymous strategy used for building consensus around risk. A facilitator uses a questionnaire to solicit ideas about important risk concerns. Responses are then summarized and redistributed to team members for further comment. This process continues until a consensus has been reached. The Delphi helps reduce bias and prevents one person from unduly influencing the outcome.[9]

The work of the team can be captured on a checklist for use as the project progresses. Segment the checklist into high-, moderate-, and medium-risk categories; use it as a monitoring instrument. While checklists are quick and convenient, they are not exhaustive. Take care to explore items that are not on the checklist, and to promote ongoing environmental scanning for risks that become evident after the list has been developed.

.2 Risk Register

The primary outputs from Risk Identification are the initial entries into the *risk register,* a key component of the risk management plan. The risk register ultimately contains the outcomes of all risk management processes as they are conducted. The register contains the following items:

- Identified risks
- Potential responses to the identified risks
- Root causes of each risk
- Documentation of risk categories[10]

For further information about risk registers, see Section 1.4.3.1.

1.4.2 Performing a Risk Analysis, Interpreting the Results, and Making Appropriate Recommendations

Risk diagramming techniques may include:

- **Cause and effect diagrams** —, used to identify the cause of the risks; also known as Ishikawa or fishbone diagrams
- **System or process flowcharts** — show how the various aspects of a system interrelate and the mechanism of causation
- **Influence diagrams** — graphical representations of situations showing causal influences, time ordering of events, and other relationships between variables and outcomes

[9] A Guide to the Project Management Body of Knowledge: PMBOK© Guide—3rd ed., Project Management Institute, 2004, pp. 247-248.
[10] ibid., p. 249

.1 The Fishbone or Ishikawa Diagram

Figure 1-8 below depicts a fishbone diagram. The head of the fish is labeled with the risk under consideration. Each fish bone is labeled with a potential risk cause. The categories typically used to identify risk cause are:

- The Four (4) M's: Methods, Machines, Materials, Manpower
- The Four (4) P's: Place, Procedure, People, Policies
- The Four (4) S's: Surroundings, Suppliers, Systems, Skills

Categories can be mixed or new categories can be added to customize the fishbone to the risk analysis at hand.

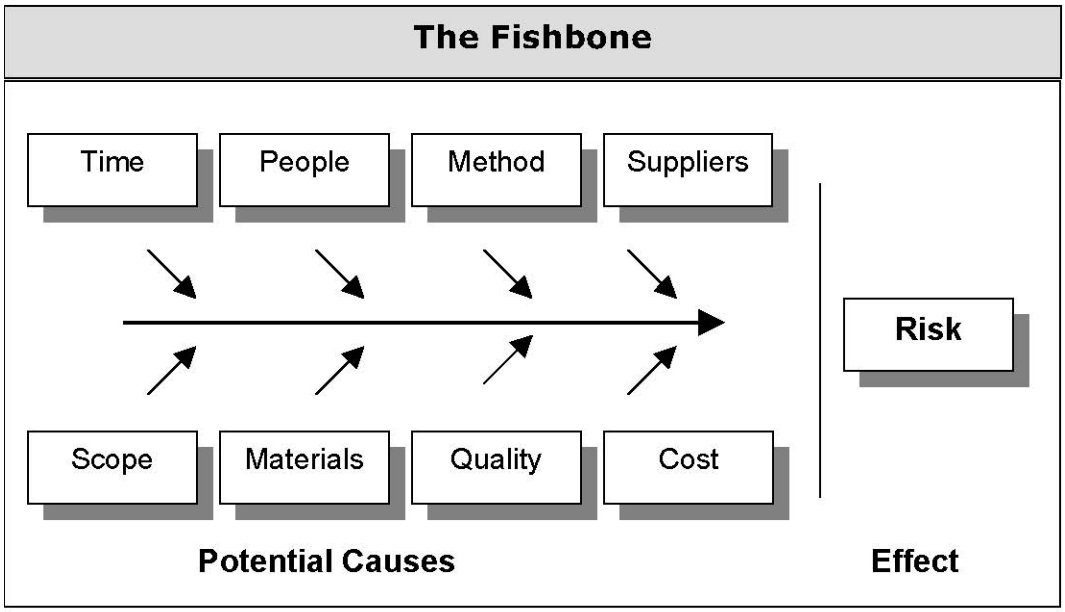

Figure 1- 8 Fishbone Cause and Effect Diagram

.2 Influence Diagrams

An influence diagram is a simple representation of a decision process. The diagram offers a way to identify and display the essential elements of a problem, including decisions, uncertainties, and objectives. It also reveals the ways the elements influence each other.

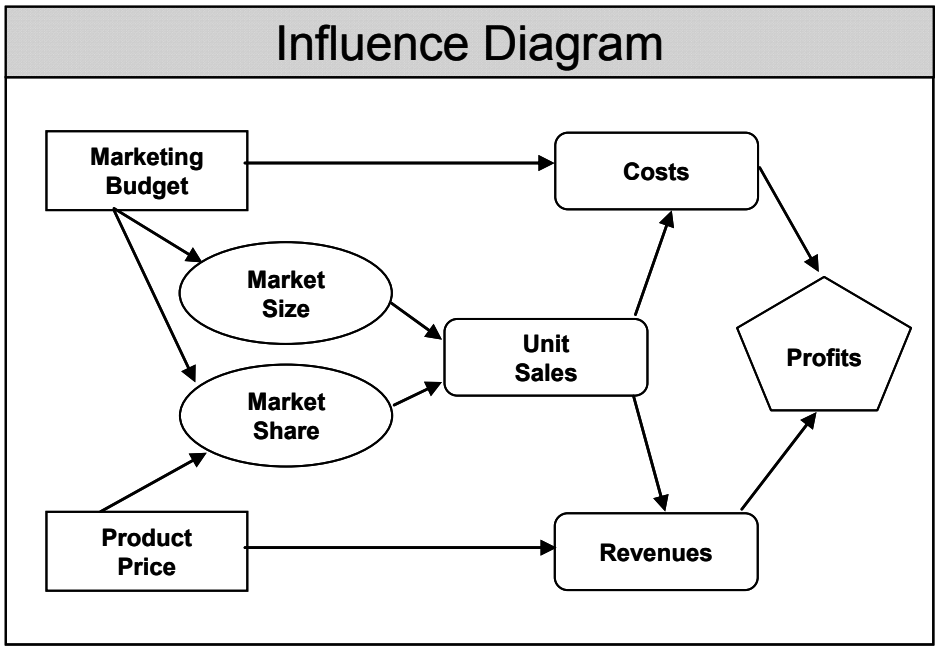

Figure 1- 9 Influence Diagram

.3 The Risk Management Plan

Once risks have been identified, develop a risk management plan. Key elements of the risk management plan include roles and responsibilities for conducting risk management activities, budgets, scheduled activities to manage risk, risk categories, definition of probability and impact, a probability and impact matrix, and a statement of stakeholders' risk tolerance. Further qualitative and quantitative risk analysis may be undertaken at this point to gain more information about each potential risk identified.

.4 Risk Response Planning and Recommendations

There are several strategies available to respond to risk. Risk analysis tools such as a decision tree analysis can be used to choose the most appropriate method(s) to apply to a selected risk. Specific actions are then developed to implement selected strategies. Primary and backup strategies can be selected, and contingency plans can be created along with identification of the conditions that trigger their use. These strategies are the basis of recommendations formulated for risk management purposes.

Three strategies deal with threats, or risks that might have a negative impact on project objectives if they occur. These strategies include avoiding, transferring, or mitigating risk.

Avoid: Risk avoidance involves changing the marketing plan to eliminate the threat, isolating the objective from the risk's impact or relaxing the objective that is threatened. Risks recognized early in the marketing analysis can be avoided by clarifying requirements, obtaining information, or improving communication.

Transfer: Risk transference requires shifting the negative impact of the threat to a third party. This action gives another party responsibility for its management, however, the

threat will continue to exist. Risk transference almost always involves a risk premium fee to the party who assumes the risk.

Mitigate: Risk mitigation implies a reduction of the probability and/or impact of an adverse event to an acceptable threshold. Adopting less complex processes, conducting more tests, or choosing a more stable channel partner are examples of mitigation actions.

Responses to potentially positive impacts on project objectives include:

- **Exploit:** This strategy is used to ensure that an opportunity is realized. Exploitation seeks to eliminate uncertainty by making the risk happen. Directly exploiting responses includes adding more talented individuals to the marketing team or providing a better quality product than originally planned.
- **Share:** Sharing allocates ownership to a third party who is best able to capture the opportunity. Examples of sharing actions include: forming risk-sharing partnerships, teams, special-purpose companies or joint ventures.
- **Enhance:** This strategy boosts the size of an opportunity by increasing its probability and/or impact through identifying and maximizing key drivers of the risk. Seeking to strengthen the cause of the opportunity, and proactively reinforcing its trigger conditions might increase probability. Impact drivers can also be targeted to increase the project's susceptibility to opportunity.

A final strategy that can be adopted to deal with either threat or opportunity is **acceptance.** This strategy can be either passive or active. Passive acceptance requires no action, while active acceptance requires that a contingency reserve be created. These reserves might consist of money, time or resources that are set aside to respond to the unknown.[11]

1.4.3 Communicating Results and Recommendations

Deciding who should be informed of the results and recommendations derived from a Risk Analysis requires sensitivity. Develop a list of primary stakeholders who need to know what risks exist and how they will be managed. A written report, an oral presentation, a slideshow, or an Intranet webpage can be developed to convey the information.

.1 Risk Register As a Reporting Tool

The risk register is developed in the risk identification phase of risk analysis. Keep it updated from the time of its development to the conclusion of the risk analysis. As a final step, add recommendations to the document. The risk register can be used as the reporting document that is communicated to appropriate decision makers. By the end of the risk analysis project, the risk register should contain the following items:

- Each risk described in relationship to its impact on the marketing plan
- Risk owners and their responsibilities

[11] ibid., pp. 261-263.

- Outcomes from risk analysis processes
- Response strategies
- Planned actions to implement response strategies
- Warning signs of impending occurrence of risk to watch for
- Budget and scheduled activities required to implement the plan
- Contingency reserves of time and cost to deal with risks that do occur[12]

Risk registers are also discussed in Section 1.4.1.2.

1.5 Trend Analysis

Marketing requires a great deal of research into customer needs, the competitive environment, risk management, forecasting, and trends in the marketplace. Two marketing tools, trend analysis and forecasting, are related processes. Trend analysis first looks at how a company's past decisions or processes yielded particular results and then attempts to harness that knowledge to better forecast what is coming next. Trend analysis utilizes a variety of techniques to generate a picture of what has happened in the past.

Six major forces influence trends: demographic, economic, natural, technological, political-legal, and social-cultural. They interact and influence each other. Macro environments, micro environments of customers, competitors, distributors and suppliers are all analyzed to produce data specific to marketing analysis. In short, environmental scanning looks at current trends, how they occurred and the factors influencing them, and then determines how to use them to predict future trends.

1.5.1 Knowledge of Basic Tools and Techniques of Trend Analysis

Two key categories of models are used to analyze trends: judgmental models and technological forecasting models.

.1 Judgmental Models

These models rely on intuitive judgments, opinions, and probabilities.

Jury of Executive Opinion: This technique is part of a set of techniques useful in situations where past data does not exist, causal relationships have not been identified or some major change has occurred in the forecasting context which is not accounted for by other techniques. The objective of these techniques is to provide logical, unbiased and systematic quantitative estimates. The techniques combine input from key informants by asking them to meet together three to four times to discuss initial estimates of trend and forecast variables. The discussion ends when consensus is reached. This approach is used widely because it is relatively quick and uses the solid understanding of participants who are presumed to have

[12] ibid., pp. 263.

relevant knowledge. However, this approach is subject to severe bias that can result in poor forecasts. The next technique specifically addresses these potential pitfalls.

The Delphi Technique: Opinions in group settings can be influenced by many things, including the dominant positions of some participants, personal magnetism, alleged expertise, and fringe opinions. Many times, this hurts the ability to have an unbiased forecast provided by the Jury of Executive Opinion. The Delphi method attempts to lessen these potential biases when making judgmental forecasts. The benefits to this approach are that it eliminates the need for group meetings and it minimizes bias. The downside of using Delphi is that it can take a considerable amount of time to reach consensus. (Note: the procedure for this technique appears in section 1.4.1.1.)

.2 Technological Forecasting Models

Some of the more useful technological forecasting models are described below.

Curve Fitting: Curve Fitting is a set of techniques particularly appropriate for very new technologies with little or no data, or very long range forecasting. Curve fitting is done to approximate the basic trend so that by extrapolating the trend, a forecast can be made.

Analogous Data: Data about another product currently on the market, or one that existed at an earlier time, can be used to forecast a new product's expected growth pattern. It is critical to establish a logical connection between the sales of the two products that serve a similar need.

Time Series Models: These techniques extrapolate past data into the future. The premise is that there is some underlying pattern in the value of the variable being forecast.

Moving Average: Data from a number of consecutive past periods can be combined to provide a reasonable forecast for next period. The greater the number of previous periods used the more “smoothing” that takes place.

Exponential Smoothing: Values in more recent time periods have more impact on the forecast and therefore should be given more weight. This method overcomes the drawback of moving averages which assigns equal weights to all past time periods.

Decomposition Models: This forecasting approach is based on the idea that a forecast can be improved if the underlying factors of a data pattern can be identified and forecasted separately. Breaking down the data into its component parts is called decomposition. The decomposition model assumes that sales are affected by four factors: the general trend in the data, general economic cycles, seasonality, and irregular or random occurrences. The forecast is made by considering each of these components separately and then combining them together.

Box-Jenkins Models: In contrast to other techniques, Box-Jenkins is a procedure which uses a variable's past behavior to select the best forecasting model from a general class of models. It assumes that any time series pattern can be represented by one of three categories of models. These categories include:

- Autoregressive models: forecasts of a variable based on linear function of its past values
- Moving average models: forecasts based on linear combination of past errors
- Autoregressive-moving average models: combination of the previous two categories

Box-Jenkins approaches to forecasting provide some of the most accurate short-term forecasts, but it requires a very large amount of data.

Regression Analysis: Regression analysis is a statistical technique for quantifying the relationship between variables. In simple regression analysis, there is one dependent variable (e.g., sales) to be forecast and one independent variable. The values of the independent variable are typically those assumed to cause or determine the values of the dependent variable.

Leading Indicator Analysis: Leading indicators are industrial and economic statistics from which an indication of the value or direction of another variable (e.g., a sales forecast) might be obtained. They are called leading because their direction or magnitude historically leads the focal variable. This technique is most useful for identifying the turning points or cyclic nature of a variable.

Input-Output Models: The processes involved in the production, distribution and sales of end products are typically comprised of several components or sub-processes. Many of these components are the same regardless of end product. Input-output analysis is used to identify these commonalities. Doing so makes it possible to better understand the processes, and by extension, create better forecasts.[13]

1.5.2 Knowledge of Processes and Methods of Manufacturing

Examples of conventional manufacturing methods include:

- Adhesive bonding
- Casting
- Drawing
- Fastening
- Forging
- Machining
- Plastic molding
- Press fitting
- Shrink fitting
- Sintering
- Welding

The manufacturing world was revolutionized by the emergence of Computer Aided Design and Computer Aided Manufacture (CAD/CAM) technology. Until the early 1970s, designs were drawn by hand. Computer Integrated Manufacturing (CIM) is a complete integration technology that coordinates every aspect of the manufacturing process. But not all progress has been in the area of automation. *Lean manufacturing,* a philosophy focused on eliminating

[13] MarketingProfs.Com, "Hitchiker's Guide to Forecasting," 2000-2006. Available at http://www.marketingprofs.com/Tutorials/Forecast/index.asp.

all the waste, often favors less automation so that plants can change quickly from one product to the next to deliver goods "just-in-time."

The evolution of manufacturing methods demonstrates how trends have influenced progress over the past three decades. Now it is simply assumed that production plans will include the use of CAD/CAM, CIM, lean manufacturing, and j*ust-in-time* tools and strategies. These innovations and their time saving advantages are included in the historical data that is analyzed while conducting a trend analysis.

1.5.3 Performing a Trend Analysis, Interpreting the Results, and Making Appropriate Recommendations

The engineering manager is responsible for ensuring that trend analysis is conducted to gain useful information about the market that is relevant to the product under development. This is achieved by using the appropriate software, selecting a team of subject matter experts to perform the analysis, and ensuring that the statistical and judgmental analysis of historical data is properly selected. Figure 1-10 illustrates the key components of trend analysis.

The Trend Analysis Process
1. Identify the objective(s) of the trend analysis. State what sort of trends to recognize. 2. Assemble a team of individuals who are best qualified to conduct the analysis based on the objective(s). 3. Assist the team in selecting the method of analysis (judgmental, technical, or both) that will generate the data specified in the objective(s). 4. Assist in the selection of the software that will be used to conduct the analysis, if software is to be used. 5. Oversee the trend analysis. 6. Facilitate the selection of recommendations based on the outcome of the analysis.

Figure 1- 10 Trend Analysis Process

Recommendations are based on the outcomes of trend analysis activities and should support accurate forecasting of future sales projections. Remember, in relationship to marketing, the primary point of a trend analysis is to ensure that, based on past experiences and current environmental factors, the product being brought to market is fully leveraged.

1.5.4 How to Communicate Results and Recommendations

It is both logical and reasonable to combine trend analysis and forecasting, since they are essentially two phases of the same study. The results of both phases can be incorporated into one report that details recommendations based on sound historical data and realistic projections for future success. The time-conscious engineering manager will consolidate these reporting tasks.

1.6 Technology Assessment Practices and Techniques

The goal of a technology assessment is to determine the capabilities of any given technology. This assessment determines whether an existing technology should be updated, replaced, or maintained when a new process is under development. They also assess a technology's safety level, effectiveness, productivity, flexibility, time saving capabilities, indications for use, cost, resource requirements, and the value it adds to the process to which it is being applied. It is a complex assessment whose benefits vary from company to company. Regardless of its context, however, the assessment's scope should always be aligned with organizational goals and strategies.

1.6.1 Knowledge of Technology Assessment Practices and Techniques

Technology assessment (Figure 1-11) is a continuous loop of three interrelated processes:

- **Technology audit:** evaluates existing technologies to assess their specifications and performance
- **Strategic planning**: ongoing research into the organization's needs
- **Acquisition**: actual purchasing decisions

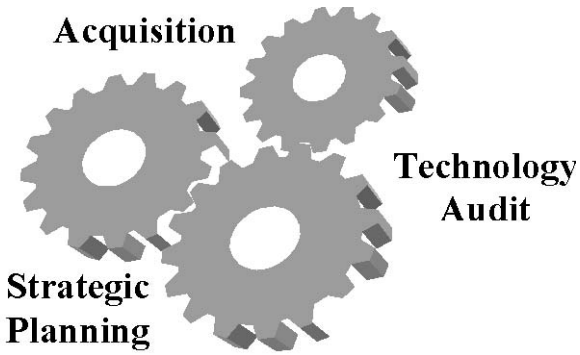

Figure 1- 11 Technology Assessment

Conducting a technology audit involves asking the following questions:

- What are the company's core technologies?
- How do these technologies define the company and contribute to its success?
- What is the company's existing technology plan? Is there an overall plan or is technology reviewed on a per project basis?
- What is the relationship between organizational strategic objectives and the technology plan(s)?
- What technologies are our competitors using? What are our peers and partners using?

- In what way are the technology strategies used by other companies effective and problematic?
- What other technology resources are available?

The answers to these questions lie in assessing company resources. Does a sufficient budget exist to acquire needed new technologies as they emerge? Will current engineering and production capabilities support the integration of new technologies, or will significant reengineering be required? Does the needed management capability currently exist or will it be necessary to train personnel to manage, coordinate and maintain new technologies? Does the current organizational structure support the integrated use of new technologies across the organization?

Next, the characteristics of the new technology under consideration must be assessed. Use the checklist below (Figure 1-12) to discover if the attributes of the proposed technology are desirable.

Characteristics of New Technology Checklist

1. Has the new technology been produced by a reputable company, which conducted thorough and validated research into the design of the technology?
2. Can the technology under consideration be customized to meet the company's specific needs?
3. Are the warranties and guarantees sufficient to ensure that the product support required will be provided in a timely and cost-effective manner?
4. Is the company that has produced the technology stable? Will it still be around when support is needed?
5. Can the new technology be seamlessly integrated with existing technologies to interface without producing insurmountable challenges?
6. Does the technology include features that inflate the product cost without contributing to its utility and applicability of its intended use?
7. Does the company already possess technologies that can be augmented, updated, or adapted to meet the existing need?

Figure 1- 12 Characteristics of a New Technology Checklist

1.6.2 Applying Technology Assessment Practices and Techniques, Interpreting the Results, and Making Appropriate Recommendations

In his article entitled "Evaluating Technology Properly," D.M. Blackburnsuggests a three-step approach to technology assessment:[14]

[14] D. M. Blackburn, "Evaluating Technology Properly," Corrections Today, 64, no. 7, 2001, pp. 56-60.

1. Technology evaluation
2. Scenario evaluation
3. Operational evaluation

Technology evaluation: Is conducted under laboratory conditions to determine the underlying capabilities of a particular technology. The technique uses a standard set of data collected by a universal sensor. The same data should be used for each technology being assessed. Technology evaluations are reproducible and usually take a short time to complete.

Scenario evaluation: Aims to evaluate the overall capabilities of the entire system in a specific scenario, rather than as a subset of the system in technology evaluations. In a scenario evaluation, each tested system will have its own acquisition sensor and so would receive different data. Because of this, scenario evaluations are not always completely reproducible; however, the approach used is completely repeatable. Scenario evaluations typically take a few weeks to complete because multiple trials are needed. For some scenario evaluations, multiple trials of multiple subjects and areas must be conducted.

Operational evaluation: Very similar to a scenario evaluation except it is performed onsite using the actual subjects and areas. Operational evaluations usually are not reproducible and typically last from several weeks to several months.

.1 Who Should Conduct the Evaluations?

Evaluations should be conducted by unbiased parties who have no stake in promoting a specific technology or product. Both technologists and practitioners should be involved in all three phases of the structured evaluation process, but the level of participation varies for each phase. Technology evaluations should be performed by technologists who are experts in the subject field. These technologists should understand the company's objective in order to establish the proper evaluation scenario. Practitioners develop the scenario so it resembles the envisioned activity, while technologists develop the test protocol so that useful data is derived. Practitioners perform operational evaluations, but technologists assist and advise in the testing and evaluation aspects of the assessment.

.2 Interpreting the Results

Clearly describe and document processes used to collect and evaluate data. Documentation will enable individuals and organizations using and evaluating the data to accept the validity of the assessment.

From the evaluation findings, assess the advantages and disadvantages of the technology under study. Advantages might include improved user productivity, faster production, enhanced user interface and lower production costs.

Disadvantages might include a steep learning curve for acquiring new skills, increased technological complexity, complications and challenges arising from the integration of the new technology with existing systems.

.3 Making Recommendations

Prior to authoring recommendations, involve others who have not been a part of the evaluation. For example, the financial staff is often aware of hidden costs that come from integrating technological innovations into present systems. Training expenses, consulting fees for implementation, increased maintenance costs, costs of the implementation or conversion, and needed software updates all factor into the decision of whether to purchase or pass on the technology.

Invest time in pursuing product reviews from former customers and independent analysts, and do not rely exclusively on data received from the evaluation. Remember, technology is always evolving and that the next evolutionary step or breakthrough could dramatically impact analysis. Technology is very difficult to predict, so keep an eye on developing technologies, as well as the product under evaluation.

Watch for developments in related fields. For example, there may be a new technology being applied in the healthcare field that can be modified and used for improved manufacturing outcomes.

.4 Reporting Considerations

Include the following information in the body of a comprehensive technology evaluation report. Remember that a formal report contains all of the components described in Figure 1-4, "Structure, Content and Focus of a Market Analysis Report."

The Technology Audit:

- Purpose and objectives of the study
- How the study relates to the mission, vision and strategic plan of the organization
- Summary of processes used and the conclusions reached as a result of conducting the technology audit

The Technology Evaluation:

- Purpose and objectives of the evaluation
- Methods used and conclusions drawn as a result of the technology evaluation
- Impact of implementing the new technology on staff duties and responsibilities, staff training and budget
- Adaptations required to integrate the new technology into existing processes and protocols, including organizational changes
- Timeframes for implementing the new technology
- Risks (both positive and negative) involved in the implementation and use of the new technology
- Input provided by other organizations or individuals who have integrated the same or similar technology into their systems
- How successful implementation will be tested and measured
- ROI analysis

Recommendations are then made regarding whether to purchase the new technology, who to purchase it from, and what features or customization is needed to fit the technology to the specific organizational needs.

1.6.3 Communicating Results and Recommendations

Once the report is written, have staff and other interested parties review and critique the report to ensure it is complete, comprehensive and accurate before presenting it to decision makers. Link the recommendations to the organizational budget or the project budget.

Remember that not all individuals interested in the report will have extensive technical backgrounds. Avoid use of jargon and include additional information such as an appendix to help individuals with less technical expertise assess and interpret study findings and recommendations. If you fail to consider the audience, you run the risk that the data will be ignored, minimized, or openly resisted.

1.7 Presentation Skills

"Presentation is everything." This statement may be a bit exaggerated, but it does highlight the importance of *how* ideas are communicated. Whether written or oral, the way in which thoughts are conveyed can produce clarity and understanding, or confusion and befuddlement. It is regrettable when the results and recommendations of an elaborate study are misinterpreted because of a faulty presentation.

1.7.1 Knowledge of Presentation Techniques, Including Hardware and Software Tools

Numerous hardware and software tools are available to produce a high impact presentation.

.1 Hardware Tools Used in Writing

Computers, scanners, typewriters, printers, ink pens and pencils are the most common pieces of hardware used as writing tools. For purposes of business writing, computers, printers, and scanners are the most common hardware tools of choice. By the late 1980's, composing on a computer became the fastest and easiest method of composition available to writers.

Scanning documents into a computer remained a challenging task until the late 1990's when optical character recognition (OCR) allowed the computer to actually read and interpret text inputted from a scanner. Often, only clearly printed text that is free of artifacts can be accurately interpreted by the computer. OCR software is advertised as the most precise, quick, and cost-effective way to convert paper and PDF files into personal computer.

.2 Software Tools Used in Writing

Word processing software is commonly used to compose written documents. There are over 100 word processing software products on the market. To open and read the documents, the reader must usually use the same software the author has used to write the document.

Alternatively, the reader may open the document using a rich text format, but the graphics and document formatting will be lost in the translation. When composing documents for others to read, the writer needs to consider what the receiver's software.

Word processing software enables users to check the document for spelling and grammatical errors, import other types of documents into the word document, create a template to ensure uniformity of format, incorporate graphics, and perform a variety of other tasks by simply clicking a button. Even with these features, documents are frequently filled with errors. This is because users do not know how to use the tools provided by the software, or they forget to use them.

Unfortunately, writers fail to proofread documents before sending them. Even the best software will not detect misusage.

.3 Presentation Software

A variety of presentation software is currently available. These programs allow the user to create slideshows and other multimedia presentations. Some types of presentation software even allow the user to incorporate PDF and text documents into the presentation. Sound, animation and graphics are easily incorporated. To create more effective presentations, become more familiar with software features. Corporate blueprinting can be added to ensure that all presentations designed by company personnel have a uniform appearance and include the company logo.

.4 Why Use a Multimedia Presentation?

The busy engineering manager might be tempted to simply hand out hardcopy text reports to listeners during an oral presentation. Asking listeners to follow along with printed material is no longer the most effective or efficient way to boost understanding and retention of information discussed

A recent report entitled "Recall of Information Presented in Text vs. Multimedia Format" from the Eyetrack III study demonstrated the effect of multimedia presentation techniques.[15] The Eyetrack III study used Eyetool technology to study a group of 46 people for one hour. During the test period, each test subject viewed mock news websites created for research purposes and real-world multimedia news features.

Two stories from NYTimes.com were edited to three- to five-minute reads and were also converted into a three- to five-minute multimedia experiences. Half of the test participants viewed the multimedia presentation while the other half of the test group was asked to read text version of the same stories. After they read or viewed a story, researchers gave the same recall quiz to both groups. Special care was taken to ensure that participants had not viewed these stories before the day of the testing. In addition to recording their answers, researchers were able to observe eye movements and fixations for participants, which added a new dimension to this comprehension/recall study.

[15] L. Ruel and S. Outing, "Recall of Information Presented in Text vs. Multimedia Format," 2004. Available at http://www.presentationhelper.co.uk/text_vs_multimedia.htm.

Study findings indicated that there was a slight, marginally significant difference in how test subjects correctly recalled story information that was presented in text versus multimedia. When asked to recall information about names and places, participants who received information in text were more likely to answer questions correctly. However, information about a process or procedure that was unfamiliar to them was more correctly recalled when participants received it in a multimedia graphic format.

What do these research findings tell us about communicating information? Engineering managers who use both text and multimedia to accompany oral presentations are more likely to reach audiences in a manner that allows them increased retention of names, places, processes, procedures and facts captured in a report.

1.7.2 Communicating in Writing

Numerous hardware and software applications are available to assist writers in composing stylish and error-free documents, but none of them will serve as a substitute for sound writing skills. Some of the most basic tips to remember when writing include:

- Write the verb section of the sentence first to avoid expressing thoughts in the passive voice.
- Avoid the use of slang words.
- Do not to use abbreviations unless appropriately defined.
- Steer away from the use of symbols such as ampersands [&].
- Avoid clichés, or at the very least, use them with caution.
- Use brackets to play down words or phrases.
- Use dashes for emphasis.
- Take great care to spell the names of people and companies correctly.
- Spell out numbers through ten. Spell out any number used to start a sentence. Use numerals for numbers greater than ten.
- Place quotation marks around any directly quoted speech or text and around titles of publications.
- Keep sentences short and to the point.

.1 Polishing Your Document

Proofreading documents helps reduce errors but will not guarantee the document presents crucial information in the best light possible. When checking written communications, make sure the document is clear and concise. Is there anything that could be misinterpreted? Does it raise unanswered questions or fail to make the point you need to get across? Can you cut down on the number of words used?

.2 Organizing Your Document

Is the written communication well organized? Does each idea proceed logically to the next? Make sure written communications are easy to read, contain the necessary information, use

facts where needed, and avoid including information that is not relevant. Close the document appropriately, making sure to include your contact information.

1.7.3 Communicating Orally

The goal of oral communications is to transfer messages from speaker to listener(s).. To do this effectively, be clear about the message, the receiver, and how it will be perceived. Weigh the circumstances surrounding the communications, such as the situational and cultural context.

.1 The Importance of Removing Communication Barriers

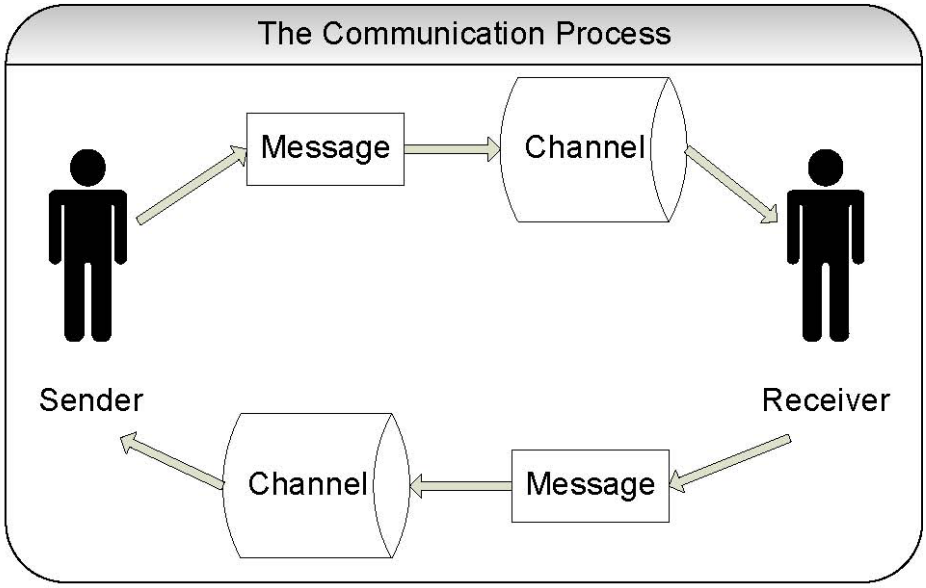

Figure 1- 13 The Communication Process

To get a point across without misunderstanding and confusion, the speaker should minimize barriers at each stage of the communication process. As depicted in Figure 1-13, this process consists of sender, message, channel, receiver, feedback, and context. Effective communicators carefully consider each of these stages:

Sender: First, establish credibility. In the business arena, this involves displaying knowledge of the subject, the audience and the context in which the message is delivered. Know your audience. Skipping this step results in delivering messages that are often misunderstood.

Message: Next, consider the message itself. Written, oral and nonverbal communications are effected by the sender's tone, method of organization, validity of the argument, what is communicated and what is not, as well as individual style of communicating. Messages also have intellectual and emotional components, with intellect allowing us the ability to reason and emotion allowing us to present motivational appeals, ultimately changing minds and actions.

Channel: Messages are conveyed through channels. Verbal channels include face-to-face meetings, telephone conversations and videoconferencing. Written channels include letters, emails, memos and reports.

Receiver: Consider the actions or reactions desired as a result of the communication. Keep in mind that the audience also enters into the communication process with ideas and feelings that will influence their understanding of the message and their response to it. To be a successful communicator, consider this dynamic before delivering your message and focus the presentation to address and influence audience reactions.

Feedback: Audiences will provide feedback in the form of verbal and nonverbal reactions to the message. Pay close attention to feedback because it is crucial to ensuring the audience understands your message.

Context: The situation in which the message is delivered is the context. This may include the surrounding environment or broader culture.

.2 The Importance of Nonverbal Communication

It's not always what you say, but how you say it. When speaking, take into account eye contact, posture, overall body language, personal appearance, voice tone, and physical distance from the listener. Remember, your nonverbal communication is often more meaningful and revealing to the listener than the words being spoken.

.3 Enhancing Your Communications

Because gestures can both compliment and contradict the message, be mindful of the following:

- Eye contact is an important step in sending and receiving messages. Eye contact can be a signal of interest, a signal of recognition, even a sign of honesty and credibility.
- Closely linked to eye contact are facial expressions, which can reflect attitudes and emotions.
- Posture can also be used to more effectively communicate messages.
- Clothing is important. Dress for presentations to show respect for the values and conventions of the organization. Be mindful of people's personal space when communicating. Do not invade their personal space by getting too close and do not confuse communications by trying to exchange messages from too far away.

.4 Speaking to an Audience

Speaking to an audience can be a rewarding experience. However, lack of preparation or not clearly defining the presentation's goals and its audience can make even the best-intended presentation a disturbing experience. To ensure the presentation is effective, first determine the objective(s). Ask, "Why am I giving the presentation? What do I want the audience to take away?"

Second, describe audience characteristics and point of view. Their familiarity with the presentation topic determines the presentation style and features.

.5 How to Structure Your Presentation

Once you have determined the presentation's objective(s) and identified the audience, it's time to structure the presentation. Begin this process by determining the length of the presentation. Take the allotted time and break it into smaller segments. Dedicate each segment to a specific task. For example, the first segment should be the introduction. In this segment, give an overview of your presentation to explain the topic, state why this topic is being covered, and express your intentions.

The next segment should tackle the first item on the agenda, with the following segment addressing the next agenda item, and so on. Once the introduction has been developed and the segments are outlined, spend some time thinking about the conclusion. The introduction of the presentation and the conclusion of the presentation are the most important parts of the total message and should have the strongest impact.

.6 Achieving Clarity and Impact

Keep the presentation short and simple. Audience members will not remember every point of the presentation, so highlight the most important parts. When in doubt, use the "tell 'em" structure:

- Tell them what you are going to tell them. (For instance, "In this presentation I will show you…")
- Tell them the key points, expanding and illustrating each one, clearly and concisely.
- Tell them what you have told them. (For instance, "In closing…" or "In summary…" and conclude.)

.7 Reinforce Your Message With Visual Aids

Next, consider the use of visual aids. Test slide projectors, data projectors, video machines and computers before use to make sure they are operating correctly and you know how to use them. Avoid packing too much information onto any single visual. A good rule of thumb is to keep each visual to six lines or less. Also, make sure any type or graphics are large enough so the audience can see clearly from all seats; and make sure the colors used are easy on the eyes, taking into account the lighting. The speaker's authority is to a great extent judged by the quality of the slides, so make sure that their design supports the message style.

If used, overhead transparencies need to be clearly marked and arranged in order beforehand. Prepare flip charts in advance when possible. When using a flip chart to take notes, make print large enough for all participants to see. While using any of these visuals, remember to face the audience as much as possible.

.8 Tips and Techniques

Additional presentation tips:

- Avoid including too many statistics or other confusing information in the presentation. Instead, consider putting this information in a participant handout.
- If you forget your words, pause for a moment and remember the objective. While the words may not come right back, this will help keep you on track and may help you to think of additional thoughts and ideas that the audience will benefit from hearing.
- Visualize yourself succeeding.
- Begin by breathing.
- Before the presentation, focus on the needs of the audience.
- Take a public speaking course at a local college or university. These are often times offered as night courses and are usually very inexpensive, while providing important confidence-enhancing skills.
- Prior to the presentation, videotape yourself delivering it. Watch the video and make changes based on observations.

1.7.4 Listening and Responding to Questions or Disagreements

The presentation has just been given. In your opinion it went well. To conclude, in a traditional manner you ask, "Any questions?" Your query is met with a resounding "Yes" from every corner of the room. With a sinking feeling, you respond with a smile and gesture to the first questioner. What are you thinking at this moment?

The fact is, you shouldn't be thinking about very much at all at that moment. This is the time to focus on the person speaking and listen.

.1 Listening Actively

It is easy for the mind to drift while listening to someone speak. The solution is active listening, i.e., listening with a purpose. That purpose may be to gain information, obtain directions, understand others, solve problems, share interest, gauge a person's feelings, or show support.

Use nonverbal communication: Use nonverbal behaviors to enhance interpersonal communication. Facial expressions such as frowns and smiles, gestures, eye contact, head nods, and your posture and positioning can all serve to reinforce, support, or dismiss the speaker's expressed concerns. Responding nonverbally demonstrates interest and concern and will keep costly and time-consuming misunderstandings at a minimum.

Give feedback: Remember that what someone says and what we hear can be quite different. Personal filters, assumptions, judgments and beliefs can distort what is heard. Repeat back or summarize to ensure understanding. Restate what you think you heard and ask, "Have I understood you correctly?" If you find yourself responding emotionally to

what someone said, say so, and ask for more information: “I may not have understood you correctly. What I thought you just said is ___. Is that what you meant?”

.2 Negotiating Disagreement

When a listener disagrees with all or part of your message, the recommended response is to negotiate with the dissenter. For a negotiation to have a win-win outcome, both parties should feel positive about the negotiation. This is important for maintaining a good working relationship afterwards.

For the negotiation to work successfully, all parties should approach the interaction as dispassionately as possible. Remember to dissociate emotions from the argument. This makes it more viable for the parties to remain friendly at the end of the negotiation.

The negotiation itself is a careful exploration of your position and the other person’s position, with the goal of finding a mutually acceptable compromise that gives both parties as much of what they want as possible. People's positions are rarely as fundamentally opposed as they may initially appear. The other person may have very different goals from what you expect. In an ideal situation, you will find that the other person wants what you are prepared to trade, and that you are prepared to give what the other person wants.

If this is not the case and one person must give way, then it is fair for this person to try to negotiate some form of non-monetary compensation for doing so. The scale of this compensation will often depend on the impact of the disagreement on the achievement of your goals. Consider of the relationship you have with the dissenter, the importance of the disputed issue, and the power distribution between yourself and the dissenter. Ultimately, both sides should feel comfortable with the final solution if the agreement is to be considered win-win.

REVIEW

Upon concluding study of *Domain 1: Market Research, Technology Updates & Environmental Scanning* managers will be able to answer the following questions regarding the principles of market analysis:

1. There are six steps involved in conducting market research. List these steps and explain what needs to be done to ensure the accuracy of the research and to analyze the significance of the data.
2. Benchmarking consists of a seven-step process of studying a competitor's best practices and looking for ways to include them in your organization's marketing strategies. List and describe the steps in this process.
3. Describe the six steps involved in business forecasting. Why is forecasting a necessary element of market analysis? What are the drawbacks involved in utilizing business forecasts?
4. Forecasting assists managers in calculating ROI. Why involve a team in determining ROI? Describe the process used to involve a team in an ROI analysis.
5. Risk analysis involves a six-step process to identify, prioritize and manage the risks associated with bringing a product to market. Describe the six steps involved in risk identification.
6. A document called a "risk register" is used to compile the results of the risk analysis and as a reporting tool to share results and recommendations with others in the organization. What information is captured using a risk register?
7. There are three models that can be used in the risk diagramming process. List the models and explain what kind of information each produces.
8. There are a number of strategies that can be used when responding to risk. Name each risk response strategy and state which strategies are used to minimize threats and which are used to capitalize on opportunities.
9. What are the six major forces that influence business trends?
10. Trend analysis examines macro and micro environmental forces that have informed past marketing efforts and will give shape to future marketing trends. Both judgmental and technological models are used to perform trend analysis. List these models.
11. List the seven steps involved in the trend analysis process. What are the benefits to be had from conducting a trend analysis?
12. List and describe the three steps involved in conducting a technology assessment. When reporting the results of a technology assessment what are the key points a manager will want to include in the report?
13. When presenting research findings to non-marketing personnel why does a manager need to consider using a multimedia presentation? What forms of media are typically included in a multimedia presentation?
14. There are a number of potential barriers to be overcome in the communication process. List each step in the communication process and describe how to overcome the barriers associated with each step.

For Further Information

- *A Guide to the Project Management Body of Knowledge* (2004) —Consult this ANSI publication for more information about risk analysis.
- The further work of D. M. Blackburn will be useful in promoting a fuller understanding of the process involved in evaluating technology.
- http://www.marketingprofs.com — provides information about the processes involved in trend analysis and forecasting.
- http://www.mindtools.com — offers a complete course on presentation techniques that will serve to augment the engineering manager's knowledge of written and oral presentation.
- For information on 3C's Model, see any of the following books or articles by Kenichi Ohmae: *Mind of the Strategist: The Art of Japanese Business,* McGraw Hill, 1991; *The Invisible Continent: Four Strategic Imperatives of the New Economy,* Collins, 2001; "Letter From Japan," *Harvard Business Review,* Publishing Division of HBR, 1995; and "Putting Global Logic First," *Harvard Business Review,* Publishing Division of HBR, 1995.

Domain 2: Strategic Planning and Change Management

Domain Champions: Stephen Long and Bjong Wolf Yeigh, Ph.D.

2.1 Strategic destinations and planning (new technologies)

- 2.1.1 Knowledge of methods for planning & implementing new technology in new destinations on a global basis
- 2.1.2 Knowledge of sources available to obtain information on competitors
- 2.1.3 Applying methods, synthesizing information, interpreting results, and making appropriate recommendations
- 2.1.4 Using available resources to formulate action plans
- 2.1.5 Communicate recommendations and action plans

2.2 System design and life cycle engineering

- 2.2.1 Knowledge of the tools and techniques of system design including system simulation tools
- 2.2.2 Phases of a project life cycle
- 2.2.3 Applying tools and techniques to compare alternative designs and select an appropriate model

2.3 Strategic Management

- 2.3.1 The Strategic Management Model
- 2.3.2 The Portfolio Matrix
- 2.3.3 The SWOT Matrix
- 2.3.4 The Life Cycle Model
- 2.3.5 Three Generic Strategies
- 2.3.6 Porter's Model
- 2.3.7 Industry and competitor analysis
- 2.3.8 Global Competition
- 2.3.9 Global Strategy
- 2.3.10 Core Competence Strategy
- 2.3.11 Developing strategies at the Local Level

2.4 Partnering and outsourcing strategies

- 2.4.1 Knowledge of outsourcing and partnering resources
- 2.4.2 Knowledge of company business and strategic plans
- 2.4.3 Establishing outsourcing relationships
- 2.4.4 Establishing partnering relationships

2.5 Risk management strategies and techniques for new technologies

- 2.5.1 Knowledge of techniques
- 2.5.2 Performing an analysis to assess the risks of introducing new technology into various markets

2.6 Change management techniques and adjustment strategies

- 2.6.1 Knowledge of change process dynamics
- 2.6.2 Knowledge of factors contributing to resistance to change
- 2.6.3 Implementing change effectively in a group or team

Domain 2: Strategic Planning and Change Management

Key Words and Concepts

Change Drivers	Events or variables that drive the evolution of industries
Competitive Intelligence Audit	A review of an organization's operations to determine what is actually known about the competitors and their operations
Data Flow Diagram	Linear representation of a system
Decision Table	A chart listing all logical conditions and actions
Decision Tree	Defines conditions as a series of left-to-right tests showing all possible paths in a design
Flow Chart	A diagram of the various steps involved in designing a system
Outsourcing	Engaging the services of third party service providers to add value to the company (streamline operations, reduce costs, reduce time to market, etc.)
Simulation	Evaluation tool formulated by creating hypothesis about what will happen in the future based on the input of different sets of variables

2.1 Strategic Destinations and Planning

The market analysis is complete. Results of the study are in and reveal that the new technology (product, process or service) under consideration will be in demand in several foreign and domestic markets. Myriad questions immediately rise to the surface.

- Will the new technology need to be adapted to meet customer needs in the new markets?
- Will economic considerations in the new market require a different pricing strategy?
- Are there political considerations to be addressed before implementing a large-scale project in the foreign market?
- Who are the competitors in the new market, and how well are they positioned to compete against your new product?
- What strategies will your company need to employ to position the new technology in the market you aim to reach?

Comprehensive strategic planning assists in answering these questions and others that arise as the planning process progresses.

2.1.1 Knowledge of Methods for Planning and Implementing New Technology in New Destinations on a Global Basis

A number of planning methods are available to ensure that new products meet target market demands. The following four approaches (Figure 2-1) combine to form a comprehensive strategic plan.

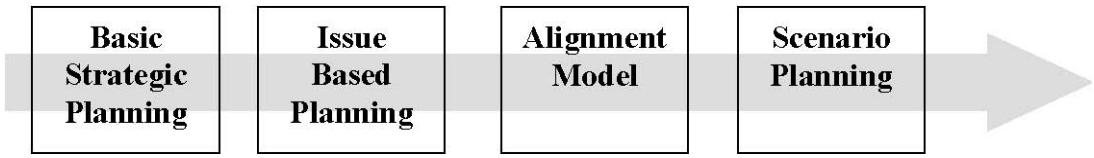

Figure 2- 1 Comprehensive Strategic Planning

.1 Basic Strategic Planning

Basic strategic plans provide the foundation for a variety of activities. These plans are created by:

1. **Identifying the purpose:** Describe the communities to be served, the customer needs, and the products and services required to meet those needs. Solicit input from upper management. (Note: this document is often referred to as a mission statement.)
2. **Creating goals:** Goals are general outcome statements that define what it is you hope to accomplish. They address the major issues associated with bringing products to new markets.
3. **Determining specific approaches or strategies to use to reach each goal:** Strategies are often dynamic and require change as more detailed examination of the new market occurs. Plan to be flexible.
4. **Identifying specific action plans to implement each strategy:** Action plans identify specific activities that each major functional department undertakes to insure effective

implementation of each strategy. They include clearly stated objectives that may be used later to measure progress.

5. **Monitoring and updating the plan:** Regularly reflect on the extent to which goals are being met and action plans are being implemented. Make changes to the plan in order to address issues identified during monitoring. When marketing a new product to a new market, feedback from the intended customer becomes an important measurement criterion.

.2 Issue-Based Planning

Issue-based planning builds on the foundation of basic strategic planning activities (see Figure 2-2). This more comprehensive approach focuses on a particular set of circumstances and places greater emphasis on the organization's relationship to other organizations (e.g., positioning, market share).

Step	Action
1. Conduct an External/Internal SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis	Examine how organizations currently operate in known markets with established products. Then, examine new markets to identify conditions
2. Facilitate a strategic analysis to identify and prioritize major issues and goals	Address internal processes and recommend modifications necessary to meet external market needs.
3. Design major strategies to address issues and goals	Set objectives and describe activities needed to meet market requirements
4. Update vision, mission, and values	Use SWOT results to recommend modifications to the defined plan purpose.
5. Establish action plans	Develop measurable objectives, indicate who will be responsible for each step of the plan, create timelines, and identify key customer contacts to work during plan execution.
6. Create the operating plan	Develop a plan for establishing the new product in the new market.
7. Develop and authorize budget for one year and beyond	Detail expected costs and revenues for a multi-year plan.
8. Conduct one year of operations	Implement the plan and review on a monthly basis to ensure that goals, objectives, and timelines are being met. Revise the plan as needed to respond to unforeseen issues.

Figure 2- 2 Issue-based Planning Example

.3 Alignment Model

As its name implies, alignment planning strives to ensure an operation is firmly allied with the organization's mission. This model is used to fine-tune strategies or to reveal why they are not working as intended. It can also be used to identify and repair organizational inefficiencies.

1. **Outline the organization's mission, resources, and support needs:** Reconcile the organization's mission with the purpose of the project. Evaluate sufficiency of organizational resources and their allocation to the marketing project. Identify and describe needed internal and external sources of support for the plan.
2. **Identify what is working well and what needs adjustment:** Assess the areas of organizational and project mission congruence, examine sufficiency and allocation of resources, and review quantity and quality of internal and external supports. Identify gaps and document what needs to be adjusted.
3. **Identify how adjustments will be made:** Create new actions plans or modify existing actions plans, as needed. Adjust financial figures to match action plans.
4. **Include the adjustments as strategies in the strategic plan:** Record selected modifications in the overall strategic plan documentation.

.4 Scenario Planning

This approach is used in conjunction with other models to ensure planners truly undertake strategic thinking. Scenario planning may also be useful in identifying strategic issues and goals.

1. **Select several external forces and imagine related changes which might influence the organization and/or the project.** These forces might include economic fluctuations, cultural differences, political shifts, regional instability and changing regulatory mandates. One source of monitoring external forces is a daily scan of world news.
2. **Discuss three different future scenarios (including best case, worse case, and reasonable case) for each external force.** Creating a range of possible futures will facilitate the decision-making process.
3. **Suggest potential strategies for responding to each of the three scenarios.** Involve several individuals with varying perspectives in the process.
4. **Detect characteristics that must be addressed to respond to possible external changes.** Look for common "themes."
5. **Select the most likely external changes to effect the organization/project and identify the most reasonable strategies to respond to the change.** Balance reliance on data with expert experience and intuition.

2.1.2 Knowledge of Sources Available to Obtain Information on Competitors

Many organizations today have established a "competitive intelligence program." Competitive intelligence programs (CIPs) can be defined as, "A formalized, yet continuously evolving process by which the management team assesses the evolution of its industry and

the capabilities and behavior of its current and potential competitors to assist in maintaining or developing a competitive advantage."[16] CIPs work to ensure that organizations have accurate, current information about competitors and a plan for using that information to the company's advantage.[17] For example, information obtained using CIP can be used in processes that supplement planning, mergers and acquisitions, restructuring, marketing, pricing, advertising, and R&D activities.

.1 Competitive Intelligence (CI) Is Different from Business Espionage

CIPs use public sources to find and develop information on competition, competitors, and the market environment. Unlike business espionage, which develops information by illegal means like hacking into a competitor's systems, CIPs use information that can be legally and ethically identified and accessed.

.2 Competitive Intelligence Needs, Teams, and Practices

Effective implementation of a CIP requires not only information about the competitors, but also information on other environmental trends (for example: industry, legal, regulatory, and international trends; technological and political developments; and economic conditions). These factors enable assessors to judge the relative strength of the competitor. In the increasingly complex and uncertain business environment, external factors are assuming greater importance in effecting organizational change. Therefore, CIP information needs are based upon the company's relative competitive advantage over the competitor — assessed within the context of environmental factors.

The most important role in a CIP is held by the organization's CI Team. That team helps to define the organization's CI needs, is responsible for collection, evaluation, and analysis of raw data, and also prepares, presents, and disseminates Competitive Intelligence. The CI team may handle all the activities itself, or it may assign some tasks to an outside contractor.

The CI unit decides on the choice of raw data sources (e.g., government sources, online databases, interviews. surveys, drive-bys, or on-site observations), It also determines if and when to deploy "shadowing" and defensive CI. Other decisions may involve choice of specialized interest groups (such as academics, trade associations, or consumer groups), private sector sources (such as competitors, suppliers, distributors, customers) or media (such as journals, wire services, newspapers, financial reports). Frequently, these issues involve balancing various constraints (time, finances, staffing, etc.) and are based on individual judgment.

---

[16] J. E. Prescott, and P. T. Gibbons, "Global Competitive Intelligence: An Overview." In J.E. Prescott, & P.T. Gibbons (Eds.), *Global Perspectives on Competitive Intelligence,* Society of Competitive Intelligence Professionals, Alexandria, VA, 1993.

[17] Yogesh Malhotra, "Competitive Intelligence Programs: An Overview," 1996. Available at http://www.kmbook.com/ciover.htm.

.3 Competitive Intelligence Audit

The groundwork for the CIP is done through an internal *Competitive Intelligence Audit,* which is primarily a review of the organization's operations to determine what is actually known about the competitors and their operations. As a starting point for obtaining CI data, the organization generally has some knowledge of its competitors and its own CI needs. Without clear knowledge of its information needs, the organization may not be able to deploy its resources effectively. The CI audit helps organizations avoid this scenario. See Figure 2-3 for sources of relevant data.

Sources	Characteristics
Government agencies	Often requires excessive lead time
Online databases	Fast method but can be expensive. Database searches provide information that has been released to the public
Investment community resources	Access to information not commonly found in online databases
Competitor's company website	Data may or may not be accurate
Surveys and interviews	Found on the competitor's website, in journals, or in white papers
Competitor's facility (drive-by and onsite observations)	Can yield useful information about the state of the competitor's business
Competitive benchmarking	Competitor's consent and cooperation is needed
Defensive competitive intelligence	Involves monitoring and analyzing one's own business activities as the competitors and outsiders see them
Reverse engineering of competitor's products	May yield important information about their quality and costs

Figure 2- 3 Sources of Competitive Intelligence

2.1.3 Applying Methods, Synthesizing Information, Interpreting Results, and Making Appropriate Recommendations

Strategic planning and CI activities are conducted to ensure that a new technology or product is a good fit with the requirements of the new market in which it is being introduced. The product must be market-led in its design, technically and commercially viable, and support the strategic plan with minimum risk.

.1 Applying Methods

Strategic planning and CI activities are often integrated processes. Assume that one of the external forces identified during scenario planning involves competitors entering the market at about the same time that the organization intends to introduce a new technology. This discovery might spur an immediate investigation to learn more about the nature of the competitor's product, practices, and market introduction strategies. In this event it would be necessary to conduct a CI audit before proceeding with scenario planning.

.2 Synthesizing Information

Checklists are useful in synthesizing information and ensuring that each step of the strategic plan is implemented in the intended order. An example of a new product introduction checklist appears below (Figure 2-4).

New Product Introduction: Ten-Point Checklist for Success

1. **Product:** Product is ready for customer consumption. All regulatory approvals and/or certifications have been obtained for the market where the product will ship.
2. **Manufacturing:** Initial manufacturing run has been completed with required yields and quality standards. The production plans are in place to support the new product ramp-up, and supplier base has been activated.
3. **Support:** Support paths have been created. Spare parts inventories have been established. User documentation, operating manuals, and maintenance instructions are ready.
4. **Sales:** Internal and external sales teams are trained and ready to sell. All required supporting materials are in place.
5. **Market Planning:** Product pricing, product structure, and packaging have been established. The launch plan ensures target markets will be reached.
6. **Marketing Collateral:** Product brochures, marketing materials, website materials, competitive analysis, and other sales tools are available to help ensure sales success.
7. **Promotion:** Advertising, PR, industry analysis, seminars, trade show plans, and other promotional activities have been established to ensure that the new product is communicated to all key stakeholders.
8. **Channels/Partners:** Required partners for the new product launch have been identified. Each partner has been trained on the new product, and proper incentive plans/contracts have been created.
9. **Customer:** Customer communications plans have been established. and upgrade paths explained. Training materials have been created and training sessions arranged.
10. **End-of-Life Management:** A plan to phase out older products has been established to minimize customer confusion, inventory risk, and end-of-life write-offs.

Figure 2- 4 New Product Introduction Checklist[18]

[18] Niti Agrawal, "New Product Introduction: 10-Point Checklist for Success," 2005. Available at http://www.stage4solutions.com/news0605.html.

.3 Interpreting Results

Interpreting results of strategic planning and CI efforts involves the use of strategic thinking and informed judgment. Results need to be weighed against the risks involved in proceeding with product introduction. The results of the CI will be used in scenario planning to imagine best, worst, and reasonable scenarios for product introduction. Risk factors that emerge need to be entered on the Risk Register and included in the risk management plan (for additional information on Risk Registers see Section 1.4.1.2). Following risk identification, analysis and planning decisions can be made.

.4 Making Appropriate Recommendations

Recommendations made by the engineering manager should consider the following questions:

- Is the extra work that will be needed to introduce the new technology to the new market within the constraints and parameters set for the overall project (quality, time, cost, risks, etc.)?
- Can we gain the needed advantage over our competitors in the new market to ensure that we are able to capture an acceptable share of the market?
- Is our risk tolerance such that we will be able to compete effectively in the new market?
- How will market introduction of the new technology impact other projects currently underway in our company?
- Will altering the new technology as required by the new market enhance or diminish product features that fuel its marketability?

2.1.4 Using Available Resources to Formulate Action Plans

Four teams will be required to formulate comprehensive action plans.

- **The risk management team** informs the plan by analyzing identified risks associated with doing business in the new market and making recommendations on how to mitigate those risks.
- **The market analysis team** contributes to the plan by providing detailed information about the target market, including: forecasted trends and economic predictions, results of benchmarking efforts, and findings garnered through qualitative and quantitative data analysis.
- **The CI team** provides information about market competitors: success strategies for new market entry, strengths and vulnerabilities, and competitors' current or anticipated market share.
- **The strategic planning team** then uses information gathered by the other teams to create the action steps that become part of the strategic plan. At this stage in the process, action steps will be informed by data alone. Financial experts are then brought in to factor the costs involved in implementing these action steps and create a project budget.

2.1.5 Communicating Recommendations and Action Plans

Action plans become a component of the comprehensive strategic marketing plan. Since strategic plans are considered highly confidential, care must be taken to share the plan with others on a "need-to-know" basis. Copies of the full strategic plan need to be secured.

The plan itself can be segmented into areas that are specific to the needs and interests of key stakeholders. The financial unit, for example, will be given action plans specific to budgetary planning. The marketing department will be given the action plans required to formulate and implement marketing strategies. Other project teams in the organization will have access to the action steps relevant to the ways in which their projects interface with the project being planned.

The engineering manager develops presentations for each functional group and presents the appropriate action items both orally and in writing.

2.2 System Design and Life-Cycle Engineering

Well thought out system design is critical to the success of any project. As the project becomes more complex, the system design becomes more complex. System design creates the opportunity to assess all risks and options before committing to a course of action in a complex project. The design and construction of a paper airplane, for example, can be completed simply and quickly. Developing systems for the design and construction of a new passenger jet, however, requires an increased attention to detail and assessment of all aspects of the project.

Life-cycle engineering provides guidelines for design — how long is the expected life of the product? Life-cycle engineering also reveals which portion of a product is the key to extending the product's life or hastening its obsolescence by identifying critical product components and their life cycle. No one expects a toothbrush to last forever. Most individuals do, however, expect longevity in the braking mechanism of the elevator they ride to the top of a multi-story building.

2.2.1 Knowledge of the Tools and Techniques of System Design Including System Simulation Tools

Some common tools used to assist with the development of the system (Figure 2-5) include:

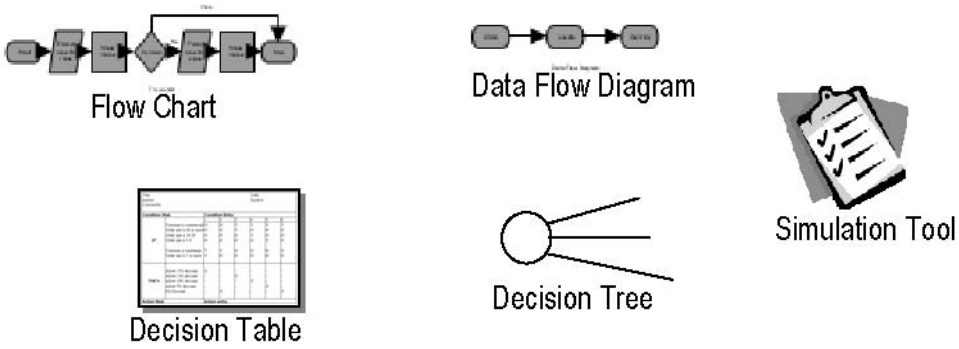

Figure 2- 5 System Design Tools

Flow chart — a diagram of the various steps involved in designing a system

- System flow charts
- Run flow charts
- Program flow charts

Below is an example of a flow chart depicting alternate paths (Figure 2-6).

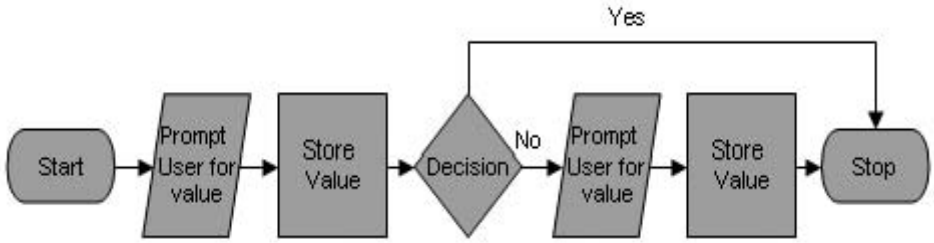

Figure 2- 6 Flow Chart

Data flow diagram — a linear representation of a system that:

- Has no data that splits into other data flows
- Has no lines that cross
- Has no flow chart loops of control elements
- Does not include activation signals

The following data flow diagram (Figure 2-7) depicts a simplified product flow from order through delivery.

Figure 2- 7 Data Flow Diagram

Decision table **—** a chart listing all logical conditions and actions (Figure 2-8).

Title:		Date					
Author:		System:					
Comments:							
Condition Stub		**Condition Entry**					
		1	2	3	4	5	6
IF	Customer is commercial	N	N	Y	Y	Y	Y
	Order size is 40 or more	N	N	Y	N	N	N
	Order size is 10-39	N	N	N	Y	N	N
	Customer is residential	Y	Y	N	N	N	N
	Order size is 5 or more	Y	N	N	N	N	N
THEN	Allow 15% discount	X	-	-	-	-	-
	Allow 12% discount	-	-	X	-	-	-
	Allow 10% discount	-	-	-	X	-	-
	Allow 5% discount	-	-	-	-	X	-
	No discount	-	X	-	-	-	X
Action Stub		**Action Entry**					

Figure 2- 8 Decision Table

Decision tree **—** defines conditions as a series of left-to-right tests showing all possible paths in a design (Figure 2-9).

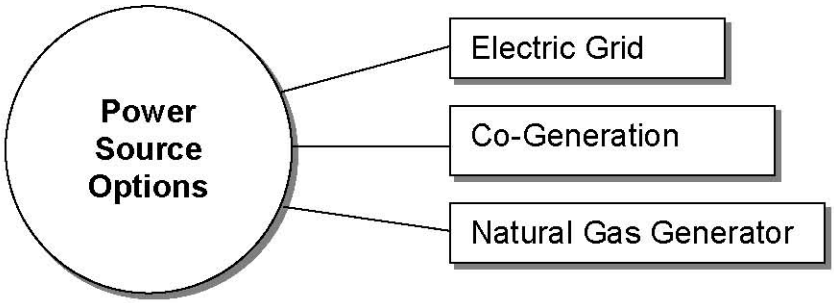

Figure 2- 9 Decision Tree

Simulation tool — models and tests systems. They reduce the time and effort required to develop the best solution, and help to identify areas where failure could occur. The expense of testing a model is significantly less than the expense of creating a full system. *Simulation* reduces the risks involved with potential failure; for example, automotive crash tests are conducted with lifeless dummies instead of humans.

Several different software companies have simulation software available. As the project becomes more complex, so does the need for a project-specific simulation. It may be necessary or desirable to develop a simulation tailored to the specific project rather than try to make the project fit the available simulations.

Putting It Into Practice: Identify the strengths and weaknesses of the system design tools you are using at work. What changes will you make to improve the processes you use?

2.2.2 Phases of a Project Life Cycle

Prior to the early 1980s, design engineers at Western Electric, the equipment design and manufacturing arm of the Bell System, designed products for an anticipated life cycle of 50 years. Following the breakup of the Bell System in the mid 1980s, design criteria were changed to reflect the market changes. What was once a captive market that demanded high quality and long-lasting equipment became, in a very short time, a free market driven by the need to compete with rapidly changing technology. Planned obsolescence reduced the product life cycle from 50 years to less than 2 years. The old Western Electric phones built in the 1970s still work. Can the same be said of today's cell phones?

Life-cycle engineering impacts both the entire system and each of its components. No system is more robust than its weakest component. The component with the shortest life cycle will determine the ultimate life cycle of the system as a whole. In many instances, project budget considerations drive the life cycle of a product's components. In other cases, the existence of product safety standards will be the determining factor in the life of the component or system.

Project Life Cycle

Phases of a project life cycle include:

- Development of the concept, including survey of competition, feasibility studies, and investigation of current technology
- Definition of objectives, targets, and controls
- Design of product or system, including assessment reviews and targets for costs, profits and performance
- Develop the marketing strategy
- Development of the system or construction of the product
- Application of the results — field testing during this phase provides the opportunity to identify and correct unexpected problems, and avoid corporate embarrassment, before product rollout
- Review of the project and lessons learned

Putting It Into Practice: Think of a product that you work with. How does life-cycle engineering impact what you do on a daily basis?

2.2.3 Applying Tools and Techniques to Compare Alternative Designs and Selecting an Appropriate Model

Each simulation model will have unique characteristics — there is no single set of parameters that is used in each instance. In order to compare alternatives and arrive at the best solution, the relationships between objectives and methods for each model should be prioritized.

Common elements of a simulation include:

- Tasks to be accomplished
- Desired yearly output quantity
- Applicable and available resources
  - Cost of each resource
  - What tools are needed
  - Time required to complete each task
  - Operating characteristics
- Transit time
- Reuse of resources
- Reuse of tools

Develop an assessment tool that takes the following factors into consideration:

- Real-life conditions of use, including misuse
- Actual environmental conditions — not highly controlled experiments that eliminate all variables
- Use by individuals who are unfamiliar with the technology
- Use by multiple individuals

Decision-making is a time-consuming task subject to human error. Decision quality can be enhanced by:

- Clarifying the objective first, then discussing strategies and risks
- Asking "Why?" more often — challenging ideas without taking the challenge personally
- Asking the so-called stupid questions. They can prevent costly mistakes.
- Selecting the best strategy

Many companies are attaining certification of their systems and processes in order to remain competitive in the global market (e.g., ISO 9000). The certification procedures require documentation of the company's products, processes, interaction with customers and vendors, and corrective action. Utilization of system design and life-cycle engineering tools and techniques will provide this documentation.

2.3 Strategic Management

Competitor Recognition

The most basic element of strategy is the recognition of competitors. Many organizations either do not recognize competitors or underestimate their importance.

Competitors are differentiated by the following factors:

- **Price.** Competitors that offer lower priced goods or services.

- **Function.** Competitors that offer better goods and services or a wider variety of goods and services, potentially meeting a wider range of customer needs
- **Time.** Competitors that offer similar goods or services more quickly
- **Place.** Competitors that offer goods or services in more convenient locations. For example, a competitor who locates an office at the customer's operating site, thus establishing a closer relationship with that customer.
- **Customer perceptions of the above.** Competitors that are *perceived* as offering better service, quality, function, convenience, etc, regardless of whether that is actually the case or not. Note: this is just as important as test data proving that the customer does offer better service, quality, etc.

Basic Elements of Competition

The steps below constitute the process management must take once it has acknowledged the existence of competitors.

1. Understand competitive behavior as a system in which competitors, customers, money, people and resources continually interact. This system is complex because all of its elements may be changing at different rates at any point in time.
2. Use this understanding to predict how a given strategic move will rebalance the competitive equilibrium.
3. Determine which resources might be permanently committed to new uses. even though the benefits of that new use may not be immediate or fully knowable. Toyota's investment in hybrid cars is a good example. The automaker committed billions of dollars to the new technology without knowing if the end product was feasible or marketable. As a result, they now have dominant market share in this growing market.
4. Predict risk and return with enough accuracy and confidence to justify the resource commitment. This requires thorough knowledge of existing and potential customers, as well as access to reliable customer data.
5. Be willing to act. The status quo is, at times, an irresistible temptress, but sticking to what one does, or continuing to do it with the hopes of minor improvement, almost always fails as a competitive strategy.

Overcoming Fear as a Motivating Factor

Fear drives an organization to the status quo. There are times when strategic changes are called for. The leaders of such an organization must be bold and see that well-conceived strategies are effectively implemented. Fear cannot be the organization's motivating factor.

Remain an Alert Defender

An alert defender has many strategies to select from. The defender can lower its prices so that the attacker cannot make enough money to survive its entry attack. The defender can encourage the attacker's suppliers to deal only with the defender. Customers can be warned of the attacker's low quality or slow shipping practices. This may or may not be factual, but the effort may be effective.

2.3.1 The Strategic Management Model

The Strategic Management Model pares strategic planning down to its three core steps:

Step 1. Where are we now?

- How do we rank relative to our competitors?
- Do we have the resources to improve?
- Are we prepared for retaliation if we make a bold, strategic move?
- What are the capabilities of our personnel resources and facilities?

Step 2. Where do we want to be relative to our current position?

- What does success look like?
- What are our organizational and financial goals?
- How do we describe the best possible--but realizable--outcome?

Step 3. How do we get from current position (Step 1) to where we want to be (Step 2)?

- What strategies will help our organization meet our organizational and financial goals?
- How do we best utilize internal resources to achieve success?

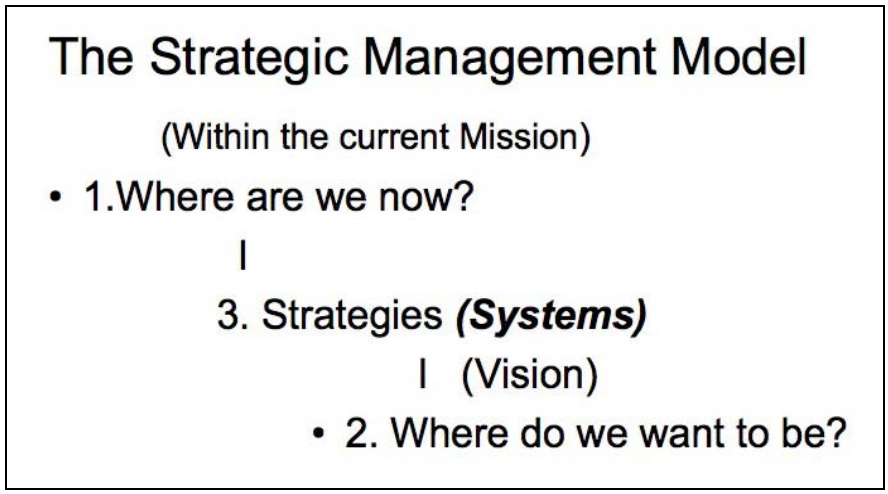

Figure 2- 10 The Strategic Management Model

The Strategic Planning Model

The process described below is based on the model shown above (Figure 2-10). It demonstrates the initial exercise an organization must perform in the formulation of its strategies.

1. Define the organization's Mission Statement and identify what business the organization is in:
   - *Airline or transportation?* American Airlines declared themselves to be in the "destination" business and diversified themselves into rental cars and hotels. It didn't last long.

- *Retail or financial?* Sears shocked the business world when they announced that they were in the financial business. That was when All State Insurance was very profitable. Sears Retail Division has not recovered from that strategy.
- *Pizza or delivery?* Domino's figured that since they deliver pizza's, they must be in the transportation business. Fortunately, their customers took little notice and there were minimal negative impacts

2. Evaluate the internal environment[19]. Determine, in depth, the following:
   - Employee demographics and capabilities
   - Financial ability of the organization to expand or retaliate
   - Adequacy of facilities for new opportunities
   - Rate of change that can be tolerated
   - The organization culture and management style
   - Access to needed skills and resources
   - Product or service leadership
   - Product or process R&D commitment
   - Planning horizon in use
   - Limitation imposed by the parent organization
   - Resources of the parent organization that may be available to support strategies
   - Level of commitment of the parent to the organization

   Analysis of this information yields strengths and weaknesses of the organization. This information forms the core of an organization's strategy.

3. Evaluate the external environment[20] and identify the characteristics of the industry under study.
   - Is the industry expanding or shrinking?
   - What is the technology level in use by competitors? Is it changing? Is more technology applicable than is in common use?
   - Is the industry stable? Have the competitors changed recently?
   - What is number and strength of competitors?
   - Are customers sufficiently strong enough to have price-setting power?
   - Are suppliers providing quality goods? Are they reliable?

   Analysis of this information reveals threats and opportunities. This is the other component to the formulation of strategies.

[19] For additional information on the role of the internal environment in the development of management strategy, see the discussion of the Integrated Management Model in Domain 7.
[20] For additional information on the role of the external environment in the development of management strategy, see the discussion of the Integrated Management Model in Domain 7.

4. Formulate and implement strategies to meet objectives.
    - Use the organization's strengths to take advantage of any opportunities identified in Steps 2 or 3.
    - Shore up any identified weaknesses through the acquisition of key resources (i.e., avoid the negative results of threats that are evident).
    - Continually rework strategy to adjust to changes in the internal and external environment

Strategic Influences

The following environmental, technological and social forces impact strategy decisions[21].

- The global environment and economy. This external environmental factor is growing in importance, but is difficult to assess. Competitors are now global, as are markets.
- Rate of technological change. Markets are being rapidly created and replaced. WiFi distribution will be considered infrastructure and continue to spread worldwide. Such a development can be either a threat or an opportunity. Either way, those in this industry must be prepared to deal with a change.
- Societal demands and changes.
    - Aging population will create service markets in all developed countries.
    - Skilled worker shortages will create education markets.
    - Emphasis will continue to shift from wages to benefits.
    - Environmental concerns will create new industries.
- Energy availability:
    - Natural gas: 25 years (recent finds may extend this)
    - Gasoline/petroleum: up to 50 years
    - Nuclear: 50 - 100 years, if we can effectively deal with spent fuel rods
    - Coal: 200+ years, but it causes ecological problems
    - Fuel cells: Currently under development. Large sizes have not yet proved practical.
    - Fusion: May prove practical in the long term, but is not feasible in the foreseeable future.

2.3.2 The Boston Matrix

The Boston Matrix (see Figure 2-11) is one of the best-known strategic models. The vertical axis of this model is Growth Rate. The horizontal axis is Market Share. Sales and financial results from recent years can be analyzed to determine which quadrant a particular division, company or organization falls within.

[21] For a study that investigates the ramifications of diminishing natural resources, see Mesarovic, Mihajlo, and Pestel,Eduard; *Mankind at the Turning Point - The Second Report to the Club of Rome*, The Signet Book Company, 1974.

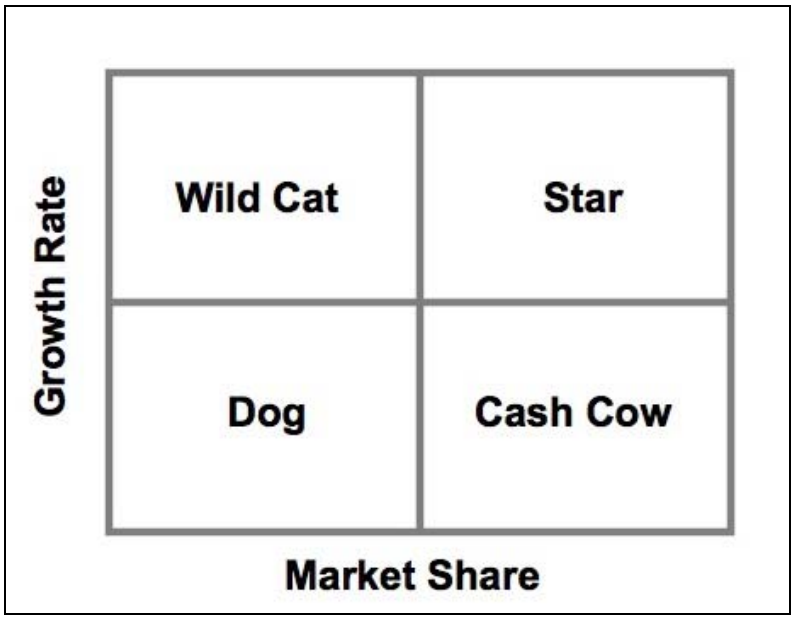

Figure 2- 11 The Boston Matrix[22]

By categorizing an organization into one of the quadrants, certain strategies are suggested. For example:

- **"Dog"** This organization, should be divested or otherwise shut down, and its resources applied to a project or organization with better returns and potential. The opposite strategy may also be elected: resources should be committed to specific areas within the organization where improvement is probable.
- **"Cash Cow"** Take the profits from this organization and invest it in more growth-oriented enterprises, i.e., "milk" the cow. Since market share is high, continuous investment needs to be made in process improvement and product research and development to maintain profitability.
- **"Wild Cat"** This organization is experiencing high growth and low market share, so with a resource commitment, it could become a "Star." Wildcats, however, are difficult to predict; many of these types of divisions or organizations never reach their potential. Management must analyze them closely before deciding to pour further resources into them.
- **"Star"** This organization type has everything going for it, both high market share and growth. Conventional strategy is to provide high levels of process and product research and development. Marketing and distribution strategies will also be needed to see that customer satisfaction is established and maintained.

There is a temptation for those developing strategies to take analyses of the Boston Matrix at face value. Good managers may find approaches that fit such situations better than the approaches suggested by this model.

[22] For a discussion of the Boston Matrix in the context of evaluating a company's product portfolio, see Section 6.4.1 within Domain 6.

The SWOT Matrix

The SWOT Matrix is also a well-known and widely-used strategy management tool. The letters in SWOT stand for: Strengths, Weaknesses, Opportunities and Threats. An organization's Strengths and Weaknesses are determined by analyzing its internal environment; Threats and Opportunities, on the other hand, are generated by an analysis of its external environment (e.g., the organization's competition). See Figure 2-12 for a sample SWOT Matrix.

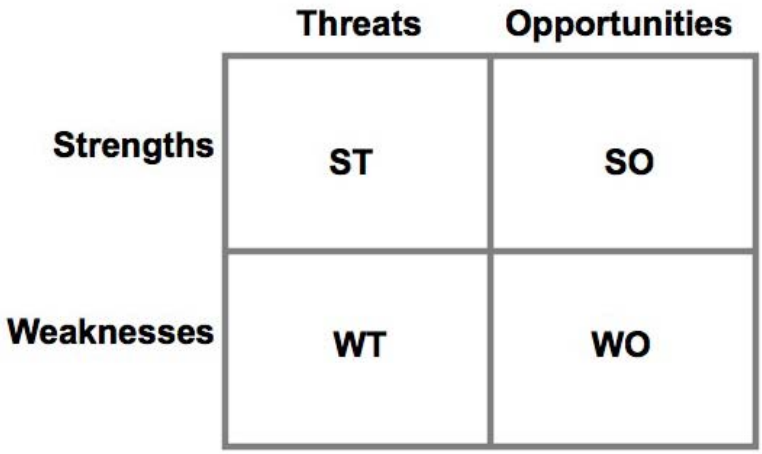

Figure 2- 12 The SWOT Matrix

Similar to the portfolio matrix, sales and financial results from recent years can be analyzed to determine which quadrant a particular division, organization or project falls within. By categorizing an organization, division or project into one of the quadrants, certain strategies are suggested.

- **WT:** If an organization lacks personnel who are competent in a key technology, but competitors do have such resources, than the organization is in the WT quadrant. The strategy would be to consider divesting the organization if access to the needed technology and resources is too expensive and time-consuming. Alternately, if licensing of the technology may solve the problem until in-house resources can be attained, and if contractors are available, then investment in the organization might be worthwhile.
- **SO:** If an organization has built up in-house capabilities and uses them in an effective team environment, they may have a strength that presents opportunities. Strategy here would be to continue to invest in personnel and expand the area of business to take on more diverse jobs.
- **WO**: This quadrant suggests that an organization invest to overcome weaknesses and take advantage of present opportunities.
- **ST**: An organization is situated within this quadrant when a competitor threatens one of its key areas of strength. In this instance, preemptive strikes may be used to put competitors at a disadvantage. Examples include reducing prices or offering more services for the same amount of money.

2.3.4 The Product Life Cycle Model

Business strategies are also be driven by a product's place in its life cycle. For example, products that are in their introductory phase—i.e., those that are still in development and have only recently been introduced to the market--require different strategies than those that are experiencing high levels of market penetration (the growth phase) or those which have already peaked and are now in a downward decline (aging stage).

Each of the product lifecycle phases is depicted in Figure 2-13 and explained in the following sections. Following the explanations are a few caveats about the product life cycle approach.

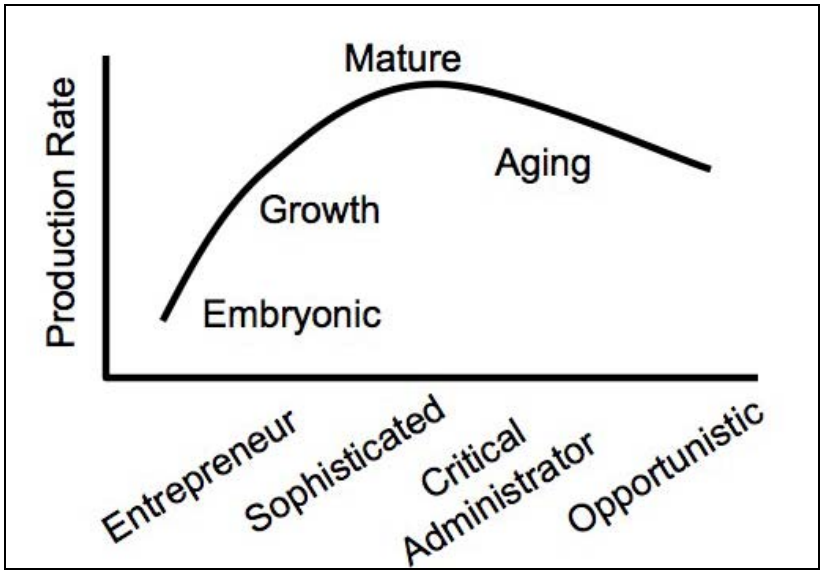

Figure 2- 13 The Product Life Cycle

Product Phase: Embryonic or Introductory

When a product is new to the marketplace, and its future, uncertain, it is said to be in its embryonic or introductory phase. While embryonic, the organization must find a market and buyers who are willing to take a chance. Buyers are usually early adopters willing to take a risk, and for whom cost is not a significant issue. There are typically quality issues with embryonic products. The manufacturing process also is still evolving as the product demand grows.

A summary of the embryonic phase follows.

- Buyers: High income.
- Products: Low quality. Design is the more marketable feature. There are frequent changes and few standard features.
- Marketing: High advertising cost/sales.
- Manufacturing: Overcapacity.
- R&D: Changing product features; Changing production techniques.
- Strategy: Use R&D and engineering to improve products and processes.
- Competitors: Few.

- Risk: High.
- Profit: Low due to startup costs. Profits increase with sales, potentially, due to high prices.

Product Phase: Growth

If a product makes it past the embryonic phase, it has found a market and sales are increasing. Product quality is also at an acceptable level, but still requires improving. Distribution now becomes an issue as the product needs to get to a broader market in a timely fashion. Competitors have also been attracted and are now beginning to advertise, but do not necessarily have the name recognition of the original product.

During the growth stage, significant emphasis is placed on research and development for both the product and the production process. The product quality improves as a result, and features are added to gain further competitive advantage. The process must shift toward mass production to lower unit cost while at the same time increasing quality.

This growth phase can be generally described as follows:

- Buyers: Growing, accept uneven quality.
- Product: Technical differentiation. Reliability is a key for complex equipment. Quality improves.
- Advertising: Higher but lower cost/sales. Advertising and distribution are key issues.
- Manufacturing: Undercapacity, shift to mass production. Scramble for distribution channels.
- Foreign trade: Significant exports.
- Overall strategy: Change to price or quality image. Marketing importance increases.
- Competition: There are many competitors. Some of these competitors may enter through mergers and acquisitions. This can provide industry experience not previously available.
- Risk: Low, covered by growth.
- Profits: Generally high.

Product Phase: Maturity

Products in this phase have significant competition from both domestic and foreign companies. Price is a key issue and emphasis is on process research and development to control cost. Product research and development should not be abandoned, however. New features may add to product life and profits. This phase is analogous to the "Cash Cow" quadrant in the Boston Matrix discussed above.

The maturity phase can generally be described as follows:

- Buyers: Mass market, approaching saturation. There are repeat buyers and brand alternatives.
- Products: High quality, less differentiation, more standardization. Changes are minor.
- Marketing: Segmentation, high-low price lines.

- Effort is made to broaden the line. Service and packaging are important. There is lower advertising/sales.
- Manufacturing: Some overcapacity. There is more stability, lower labor unit cost, longer runs, process improvement. Distribution channels are refined for efficiency.
- Foreign trade: Few exports, some imports.
- Strategies: Maintain market share. Control costs. Marketing effectiveness is important.
- Competition: Heavily oriented to price. There are more private brands. More foreign competitors.
- Risk: Cyclical. Periodic price wars and advertising campaigns can be expected.
- Profits: Lower but may be partially offset through high volume.

Product Phase: Decline

Managers take pride in developing successful products, so few are prepared to do a good job of managing a declining product line. The last phase of such a project is frequently the shut down of the facility, dispersion of assets and termination of employees.

Conventional wisdom indicates that such products must be divested by the most expeditious method possible. Managers' emotional tie to the product and the people associated with its production make this difficult to execute. Many companies bring in a new team of managers to oversee the shutdown. Note that this strategy is similar to the one taken for organizations or products in the "Dog" quadrant of the Boston Matrix.

In those instances where divestment is not an immediate option, the overall strategy becomes to control cost. There may be opportunity, for instance, to acquire competitors at a steep discount, thus reducing supply and increasing the likelihood of continued profit. Another option is to find new or niche markets. Under-served customers like those in the developing countries should continually be sought out.

General characteristics of a product in the decline phase are as follows:

- Buyers: Sophisticated, with high bargaining power.
- Products: There is little product differentiation and varied quality.
- Marketing: Low advertising/sales and other marketing costs are the norm.
- Manufacturing: Substantial overcapacity and mass production. Specialty channels; discount stores, house brands are common.
- R&D: Little to none.
- Foreign trade: There are no exports and increasing imports.
- Competition: Several competitors exit the business. There are fewer competitors.
- Profits: Low prices and profits. Profits may rise in late decline.

Extending the Product Life Cycle

Every organization wants to extend the product life cycle as long as possible. This is normally done through both product and process research and development. Additional features can be added so that the product will hold market share. Process improvement can

increase efficiency so that profitability can be maintained. Occasionally, new markets can be identified for a new version of the product. For example, there are now cell phones targeted for the elderly and for children.

Caveats Regarding the Product Life Cycle Approach

The standard Product Life Cycle should not be applied to all products and industries in the same fashion. If a company changes with the times and the marketplace, for instance, life cycles can be drawn out or eliminated. Similarly, life cycles are highly specific to a product and/or industry. Hoola hoops and wall walkers, for example lasted days, while rotary telephones lasted several decades. Cell phones, by comparison, have a much shorter life cycle.

2.3.5 Three Generic Strategies

The three generic strategies discussed in this section are: overall cost leadership, product or service differentiation and focus. The latter two, differentiation and focus strategies, are both low market share strategies; low cost leadership is a high market share strategy. Because they contend with different levels of market share, the two sets are mutually independent (i.e., it is difficult to change from a product differentiation strategy to that of a low cost leader for reasons that will be more fully explained below).

Cost Leadership Strategy

Those organizations deploying an overall cost leadership strategy demonstrate the following characteristics:

- Efficient, scalable facilities
- Cost reductions through production experience
- Cost and overhead control
- Investment in facilities and research and development (R&D)
- Efficient distribution

The benefits of being a low cost leader are as follows:

- Good return on investment and sales
- Good defense against competitors
- Reduces power of suppliers
- Raises entry barriers for potential competitors

Companies using this low cost leadership strategy include Lincoln Electric, Briggs and Stratton and Whirlpool.

Be aware that potential competitors might utilize the following strategies to cut into a low cost leader's market share and profitability:

- Low price entry, with a competitive advantage such as low labor cost or a perceived higher quality product or service.

- If a competitor has an R&D breakthrough, it could compete on the basis of the new and better and perhaps cheaper product. A competitor with a more efficient operation, higher quality, longer life, higher reliability, etc., could challenge an entrenched company.
- A company with a superior, differentiated product or service could be an effective challenger. The challenger must be perceptively better in some significant respect in the eyes of the customer.

As a cost leader, you potentially face the following challenges:

- Highly technological firms may offer a more sophisticated product that would make old R&D a sunk cost.
- On the other hand, the challenger may develop a product that few customers want. One major company wanted to make an entry to a new market with a new programmable logic controller for manufacturing organizations. It had every conceivable feature that any customer might want. Customers, however, preferred less expensive, less complex controllers with limited specialized functions.

Product or Service Differentiation Strategy

The differentiation strategy involves ensuring that your service or product is perceived as significantly different from those of your competitors. Designer label clothing and accessories are two clear examples, as are Lexus automobiles, Jenn-Air appliances and Honda power equipment. This is by nature a low market share strategy. If many customers were able to buy these products, they would lose their appeal as high-end, exclusive product lines.

Advantages of the differentiation approach include:

- Perceived uniqueness
- Reduced price sensitivity
- Higher profit margins
- Reduced threat of substitution

Disadvantages of the differentiation approach include the following:

- May preclude high market share and its benefits.
- Makes quality extremely important
- Must have strong marketing capabilities
- Must have strong product engineering
- R&D and innovation are at a premium
- Must attract and hold highly skilled people

Competitors attempting to cut into the market share of a company using a differentiation strategy might attempt the following:

- Standardize the product at a high quality. Copy and improve it. The Japanese did this with automobiles extensively and gained significant market share at US manufacturers' expense.

- Offer a complete range of models/brands within a product line and price them competitively. This is, in effect, creating a one-stop shop that sells all product models/brands, not just high end or low end. This appeals to customers who do not want to spend time looking for multiple suppliers.

Focus Strategy

When deploying a focus strategy, a company *focuses* its efforts on one geographic region, a narrow demographic, a particular industry or one product line. This strategy works best when the company has natural advantage in a particular segment of market. For example, a company might concentrate its efforts on a geographic market where it knows local buying habits or focus on the production of one product that it is an expert at manufacturing. The idea is to make high profit with limited sales, while remaining small enough to avoid attracting the attentions of large competitors.

Examples on companies using a Focus Strategy include:

- **Geographic Focus**: Many restaurants were regional before expanding. Shoney's and Cracker Barrel are regional organizations.
- **Industry Focus**: A few tool companies sell only to local auto repair shops and do not attempt any conventional retail sales. The construction industry has many suppliers that cater to that one industry.
- **Product Focus**: Stuckey's, Kroger and Krystal restaurants are examples of companies that use a focus on food sales. Several food companies such as ice creams, dairies and sausage companies also use the focus strategy.

Strategies to use against a company deploying a Focused approach include the following:

- Low price entry. This can be devastating. Large, well-financed competitors enter a market with cost advantages and can take market share easily. They must take much of the market to generate sufficient profits. Such companies can buy a local competitor and attack the remainder of the local market.
- Heavy marketing. Small companies often do not have adequate resources to counter a bigger competitor's mass marketing.
- Specials: Competitors can offer specials similar to the defender's primary products. This "low price entry" approach can be effective in an industry with low profits.
- Use of distribution system to increase service and reduce cost: Distribution is usually a high cost item for small industries. Competitors with better systems can make more frequent deliveries from larger warehouses. This can aid an invader against a company using a focus strategy.
- Offer broader line of goods and services as discussed above.

The Bath Tub Curve: The Challenges of Switching Generic Strategies

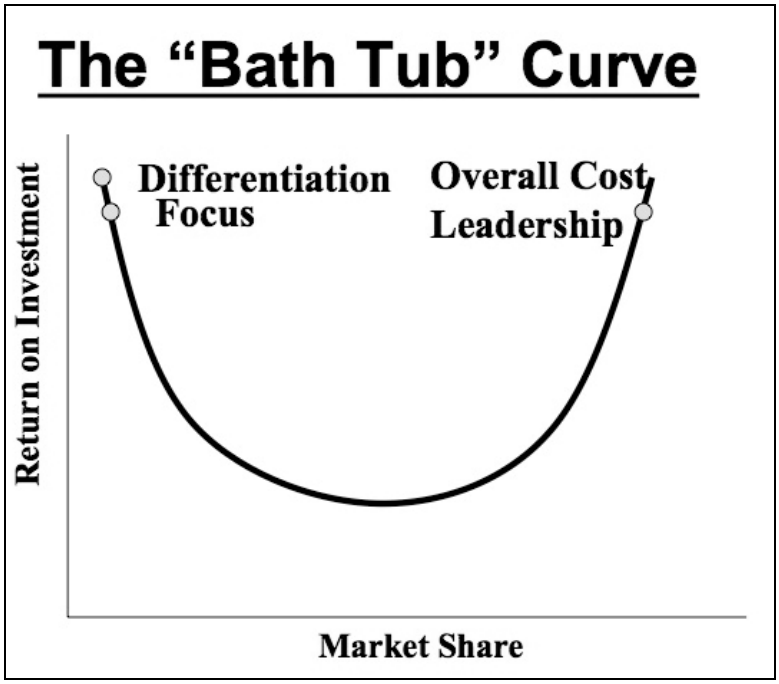

Figure 2- 14 The "Bath Tub" Curve

The curve shown in Figure 2-14 demonstrates the differences among the three generic strategies from an ROI (return on investment) and market share perspective. Both Differentiation and Focus, for example, are represented as low market share strategies. Low Cost Leader is a high market share strategy. ROI is high for all three.

If a Focus strategy organization decides that it wants to become a low cost leader, significant financial resources are required. As market share rises, return on investment declines. If the organization does make its market share goals, it gets trapped in the "death valley" or minimum return on investment portion of the curve. This failed attempt to capture market share can doom the organization. It is neither low priced nor focused.

Porter's Model

Porter's model, as depicted in Figure 2-15 below, was developed to show how elements of the strategy relate to each other. [23]

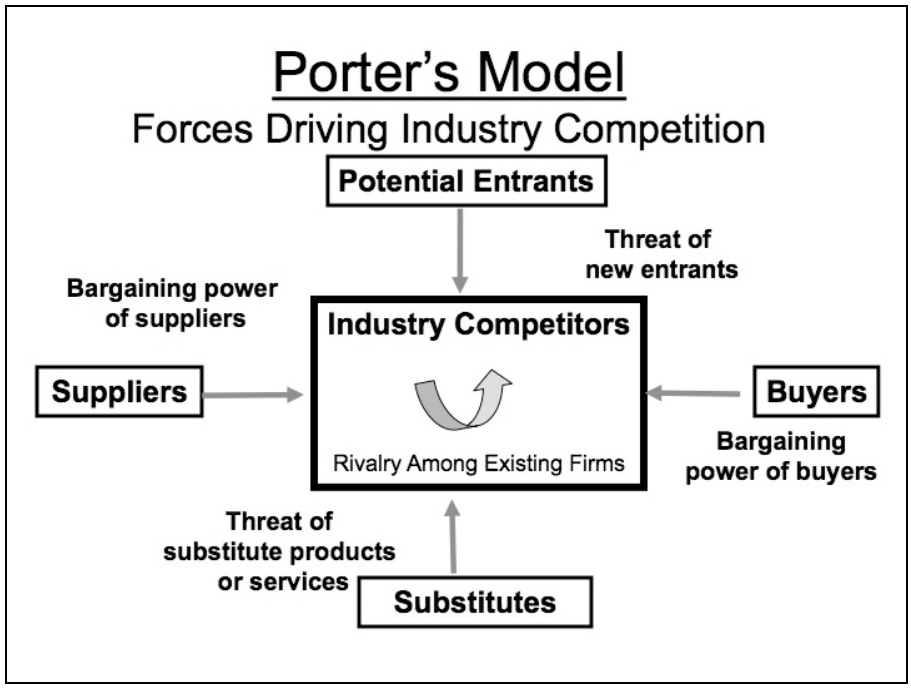

Figure 2- 15 Porter's Model

Strategy Considerations

Porter's Model suggests that a company must consider more than just the competition as it formulates its strategy. It must also think about:

- Potential Entrants
- Buyers (Customers)
- Substitutes
- Suppliers

The box at the center of the Porter Model depicts the position of industry competitors relative to these four considerations.

Threat of Entry

In strategizing, companies must consider both *known* and *potential* competitors. *Potential* competitors are those who have not yet entered the market, but who might pose a serious threat at some later date. These include foreign companies that may be relatively unknown in the US, but who should be considered nonetheless.

[23] Porter, Michael E.; Competitive Strategy; Free Press, 1980

The following strategies may be used to bar new entrants from effectively entering the marketplace:

- Economies of scale
- Product differentiation
- Capital requirements
- Switching of costs
- Prohibitive distribution costs
- Cost disadvantages independent of scale
    - Proprietary product technology
    - Favorable access to raw material
    - Favorable locations
    - Government subsidies
    - Learning or experience curve
- Government policies or regulation
- Anticipated retaliation
- Deterring price of entry

Note that entry barriers depend on condition and context. A rise in petroleum prices, for example, may impact foreign competitors more than domestic companies depending on the importance of exports to those domestic companies.

Similarly, Large-scale operations can make it more difficult for a new entrant via low-cost operations. If the new entrant has a technological advantage, however, the large-scale competitor may be at a *dis*advantage as it has a heavy investment tied up in outdated facilities. Another disadvantage of scale is that it tends to lower product differentiation, potentially making entry more viable.

The Bargaining Power of Buyers

The buyer or customer can play a large role in the success of a company. If the customer can control prices, for example, then his strategic impact is immense. He has the potential to force down prices and profits. This is especially true when one customer buys a large proportion of the company's total goods. In those instances, the customer informs the seller of the price that he is willing to accept.

If the seller is unimportant to the customer, the seller has little control over prices. The customer can get the product or service from other competitors or provide them internally.

Customers are also powerful if:

- Products are standard or undifferentiated.
- There are few switching costs.
- Buyer has low profits and requires price concessions from the seller.
- Buyer can potentially backward integrate.

- The product or service has little impact on the quality of the buyer's product.
- The buyer has full information, especially information on the seller's costs.

The Bargaining Power of Suppliers

Suppliers have bargaining power with a seller in the following instances:

- Supplying industry is more concentrated than the buyer's.
- There are few better alternatives for the buyer.
- Few substitutes are available to the buyer.
- The buying industry is not important to the supplier.
- The supplier's product is important to the quality of the buyer's product.
- The supplier's product is differentiated or switching costs are high.
- The supplier can potentially forward integrate.

The Government as a force can either raise or lower entry barriers through tax incentives or regulations. This impacts a supplier's ability to its prices and their ability to be competitive.

2.3.7 Industry Competitors

Below is a list of factors that affect the intensity of rivalry among competitors.

- **Cost** of production, advertising, new product introduction, customer service and warranties
- **Numerous Competitors** When there are numerous, equally balanced competitors, instability is more likely and the impact of strategies less predictable. Competitors make moves without expecting retaliation.
- **Slow Industry Growth** Competition intensifies as industry growth slows. Market share becomes increasingly important.
- **Lack of Differentiation or Switching Costs** Price and service competition is intense.
- **Capacity Augmented in Large Increments** The capital requirements involved in this strategy increase risk. Steel companies are in this boat.
- **Diverse Competitors** Differing goals makes strategy formulation more difficult. Higher priced organics food products from small companies, for example, compete with similar products from food conglomerates. Unit profit is much more important to the smaller producers than to the conglomerate who has economies of scale.
- **High Exit Barriers** Specialized capital equipment with low salvage value makes exiting a market difficult and expensive. Labor costs are high when contracts call for severance packages. This raises exit barriers. There are also emotional barriers, such as ties to the community, which make exits difficult. Government regulations also add cost to a shutdown or layoff.
- **Pressure from Substitute Products** New products provide the same service in a completely different way. The alert strategist must be aware of new products long before

they are introduced. Examples include: artificial sweeteners impacting the sugar market and flat screen televisions replacing CRT models.

2.3.8 Global Competition

The globalization of information has led to global competition in most industries. Industries with high transportation costs never expected the degree of competition from foreign companies they are now experiencing. Many foreign brands have high name recognition and a reputation for quality within domestic markets.

Supply chains frequently involve several nations. The brand recognition that suppliers generate makes those countries a potential for retail sales. These same suppliers employ local workers who have access to dependable wages. These workers form a new middle class that demands consumer goods. The world economy is expanding in this manner. Recessions, however steep, do not reverse this model, but the rate of expansion does slow considerably.

The basic reason for global competition is economies of scale and the opportunities brought about by information technology. Similar products can be sold worldwide from the same design and marketing. The potential for profits increases exponentially with global sales.

The goal is to make and sell the same product in as many markets as possible. The actual situation, however, is rarely that simple. Coca cola is the same worldwide. Fast food chains make menu changes that appeal to local populations while they attempt to add their traditional products to the new market.

Many successful global companies manage as if all markets were the same distance from headquarters. Most, however, do not. They manage the home market as if it were the real business and the rest as if they were there for additional market share and profit. This is a short-term perspective that is not adequate to long-term global success.

Geography without Borders

Information has made the world truly global. Almost anyone in the world can watch CNN or go online and find out what is going elsewhere in the world. Prior to the explosion of information technologies, many of the world's citizens were at the mercy of their governments for information distribution. Now it is much easier for any organization to find out about any country or region it is interested in. The role of government, in this respect, is diminishing, although still felt in certain areas of the world.

English has become the international language of business. Italians, Japanese and German companies with global interests now communicate in English. Language is a major disadvantage to US industry whose leaders are less conversant in foreign languages than their foreign competitors.

2.3.9 Global Strategy

Insiderization

The establishment of local manufacturing and distribution systems is called insiderization.[24] This occurs when most of an international company's regional organization is made up of locals. Sony, Honda, and Nissan, for example, have become insiders within the US. Because

it is too expensive to ship all parts from Japan as they originally did, these companies make parts and products within the US. This is advantageous both financially and politically.

Coca Cola's Japan operation provides another example. In order to sell its product in Japan, Coca Cola had to develop an entire Japanese operation. Coke developed their own route salesmen, trucks, bottling companies, etc., and initiated a large-scale local marketing campaign. They did not do everything right, but they finally did everything.

Pharmaceuticals would be entirely different. The US model would not work with Japanese doctors. They have specific requirements of drug salesmen.

Where is the Headquarters?

When new overseas operations are struggling, management is only too willing to let the on site people handle things. Once some measure of success is gained, the situation reverses. The new operations, for example, are expected to follow home office accounting systems. Headquarters begins making decisions for the local offices and immediate profit is expected. If this does not happen, headquarters makes immediate changes to local management. They forget the requirement for long-term investment and patience.

Successful global companies build regional headquarters in major markets and staff these offices with the best talent available, regardless of the nationality of the executives. Strong headquarters in the home country soon discover problems in foreign markets and do not have the background in local conditions to solve them. They fail to recognize that the problems are really at headquarters, not across the ocean.

Thinking Global

There must be local management in each region where there are strong operations. Clone the parent and let the clone manage to meet local needs.

Strategies

Effective world competitors incorporate superior quality and reliability into cost structures. Marketing, service and distribution all must be tailored to the local market. Low cost entries to foreign markets can only be executed in market segments that are significantly underserved, as local competitors have a natural cost advantage. Initial outlay of capital is critical to expanding into a foreign market. Many companies find local partners to reduce the risk and obtain valuable information from them before a major expansion.

[24] Ohmae, Kenichi; "Managing in a Borderless World," Harvard Business Review, May-June, 1989.

Companies with major technological advantages are likely to expand globally. Such advantages may be short lived, so windows of opportunity are short. Those who capture market share early tend to be more profitable over time. Even so, continued innovation is required to maintain technological leads.

2.3.10 Core Competence Strategy

In the middle and latter part of the twentieth century, vertical integration was the dominant strategy of the large corporation. Vertical integration allowed a company to control the entire production process, perhaps from raw material sources, raw material processing, subassembly and final assembly manufacturing. Guaranteeing that each level of the chain had a large customer without the added cost of advertising and sales made an efficient vertical supply chain. This concept was followed by General Motors and many large-scale manufacturers. The chain was never absolute but it was substantial and offered economies of scale that were difficult to compete with.

Over time, however, competition became global, and the vertical integration model was not effective against foreign companies with wage advantages. Many of these companies were in Japan, and they used a different system of manufacturers and suppliers. Major companies had specified suppliers that worked together as a team. Designs were developed so that suppliers could use their strengths to make the final product better and cheaper. The allied suppliers were known as Keiretsu. Their combination with major companies such as Toyota made a formidable competitor. These suppliers shared not only ideas but employees. When a manager in the primary company retired at the age of fifty five, as was the custom, he went to work with one of the keiretsu companies. Vertical integration was no match for the keiretsu system. Vertical integration required massive amounts of capital to acquire suppliers that were not always the most efficient organization of its kind.

The next iteration in the development of strategic moves was the core competence of the corporation.[25] Core competencies are knowledge bases upon which the corporation builds its competitive advantages. In this day of mergers and acquisitions, several major corporations have made decisions based on profits and growth in market share, only to later discover that they did not have the knowledge to expand and competitors did. GTE is cited as an example, as is NEC, who is cited as a company of modest resources that was able to buid its core competencies and gained strength and success as a result.

A New View of Corporate Innovation

In the world economy it is essential to create products that customers need, but have not yet imagined. The top managers of Western companies must assume responsibility for their competitive decline. It is easy to blame "unfair" competition, lower wage rates, etc.

The emergence of technology development creates opportunities for new products and services. Products and services that exploit the convergence of technologies create markets that were unknown but needed. Putting technologies together allows for the development of unique products and services. Microelectronics and optics are responsible for several modern products from fax machines to printers to copiers and optical scanners.

[25] Prahalad, C.K., and Hamel, Gary; “The Core Competence of the Corporation”; Harvard Business Review, May-June, 1990.

This concept allows for the maximizing of existing resources and the minimizing of resource expenditure. US companies frequently spend millions on research in hopes of a breakthrough that can effectively be translated into competitive products. Once the products are developed elsewhere, they are shocked that someone else has learned of the development and introduced a superior product. How does that happen?

Any company that has core competences in the areas of the new product is in good position to develop a superior product. Unless the developing company has the competencies in all areas of technology of the product, they are unlikely to maintain control of the market.

The Roots of Competitive Advantage

The diagram below (Figure 2-16) depicts the product production logic within a company that organizes itself around its core competencies.

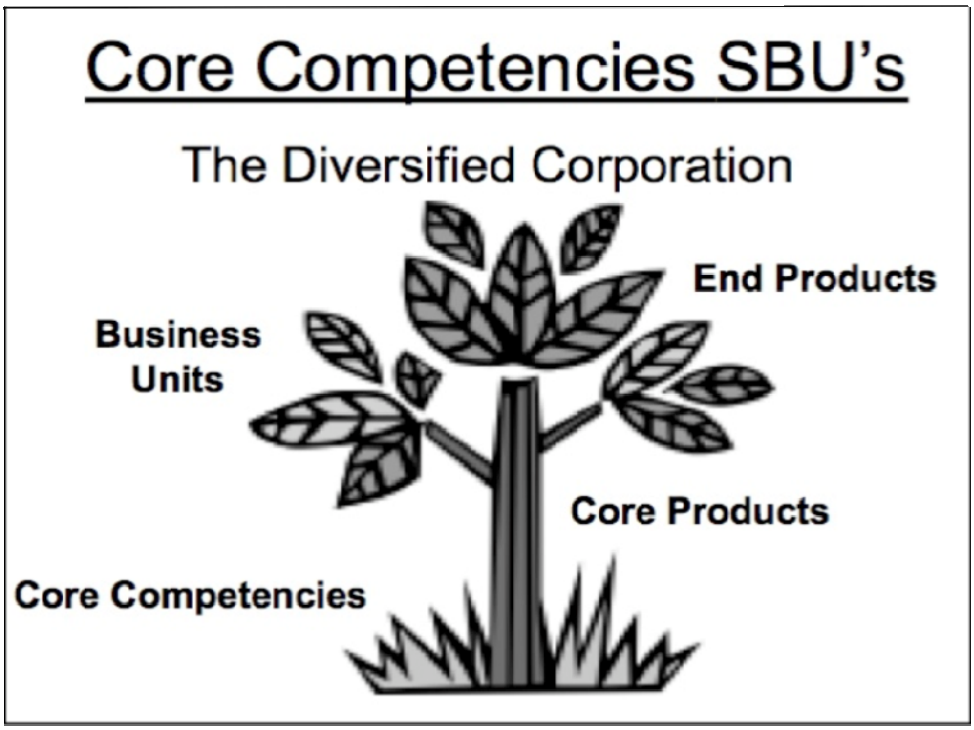

Figure 2- 16 Production Logic for Companies Organized around Core Competencies

In the illustration, the roots of the tree represent a company's core competencies. The trunk of the tree represents the company's core products, all of which are developed from the core competencies. They are not end products. They may take many forms based on the core products. For example, in the 1980's Honda was losing out to Japanese competitors in motorbikes and motorcycle sales. They had previously enjoyed a high market share and profit. Both began to slip as competitors made significant improvement in their products. Over a two-year period, Honda completely redesigned their small engines and the products in which they were used. Their engines became world-class core products. These engines were put into motorcycles and bikes, smaller versions were put into generators, lawn mowers, power washers and many more products. Honda developed a core competence in the design and manufacture of small engines. The engines were core products that went into many end products.

The limbs of the tree represent the company's business units. These business units organize the core products into end products, represented here by the leaves. Business units innovate by finding new ways to combine core products, and/or new markets for their distribution. Business units may also combine core products with supplier-provided technology to create new end units. The concept is not binding but free-flowing.

Other characteristics of core competence include the following:

- Core competencies are enhanced as they are used and shared.
- Core competencies harmonize streams of technologies.
- Core competence is communication, involvement and a deep commitment to working across organizational boundaries.
- Core products contribute to the competitiveness of a wide range of end products. Honda developed a competence in small engines. They used this competence to make a range of high-end products in lawn mowers, generators, leaf blowers and other products.

Competencies should not be thought of as bundles of business-making products. They should be considered, rather, as bundles of technologies used collectively to create products. Systems integration skill is a fundamental key to core competency's success.

Identifying Core Competencies

To identify an organization's core competency, utilize the following criteria:

- Does the competency provide potential access to a wide variety of markets?
- Does it make a significant contribution to the perceived customer benefits of the end product?
- Is it difficult for competitors to imitate?

Note that few companies in the world will master more than five or six core competencies.

Core Competencies Generate Core Products

Core products are the components and subassemblies that actually contribute to the value of the end products. To sustain leadership in their chosen core competence areas, companies must maximize their world manufacturing share in core products.

As a company multiplies the number of application arenas for its core products, it can consistently reduce the cost, time and risk in new product development. Well-targeted core products can lead to economies of scale and scope.

Limitations of Strategic Business Units

The Strategic Business Unit (SBU) is a unit that:

- Has control of its own resources, budgets and revenue
- Develops and implements its own strategy: research and development, product development, advertising
- Controls key personnel: can acquire and pay key contributors

The SBU is not a good device for integrating technologies. They are rewarded for succeeding independently, not for working cooperatively with other SBUs.

Problem Areas:

- Under-investing in developing core competencies and core products
- SBU managers tend to compete with each other and cut costs more than invest.

Constrained Resources

The SBU manager is reluctant to lend its key people to another SBU and have them succeed. They tend to hide talent rather than promote it. This is like hiding money under a mattress rather than investing it.

SBU managers are perfectly willing to compete for cash, never think of competing for human resources.

Top management pays a lot of attention to the capital budgeting process and so little to the human resources that embody core competencies. They seldom look four or five levels down in an organization, identify people who embody critical competencies, and move them across organization boundaries.

Limited Innovation

Innovation in SBU's is limited to existing product lines due to lack of access to resources. Existing lines may be extended and geographic boundaries may be extended, but multi-technology innovation is very unlikely.

Developing Strategic Approaches

Boundaries within the SBU model are as follows:

- Fragmentation of core competencies
- Information systems that are not shared between SBUs
- Pattern of communications that hold information internally
- Career paths – no opportunities outside the SBU
- Managerial rewards – rewarded for local success not contribution to corporate success
- Strategic processes that are independent of corporate strategy

To be successful, strategic architecture must make resource allocation transparent to the entire organization. For example, the best ideas get the most product development funding. Additionally, the business units must provide technical and production linkages (i.e., communication) across organizational lines.

Taking Advantages of Competencies

SBU's should bid for core competencies the same way they bid for capital. Top management must identify overarching competencies, and ask businesses to identify projects and people closely connected with them that will form competitive products.

Core competencies should be viewed as corporate resources that are to be effectively spread across its businesses to yield the highest payoffs. Reward systems must be adjusted accordingly. Managers who provide key resources to other businesses at the expense of their own bottom line must be recognized as making a significant contribution to the corporation.

Also, management should ensure that key people understand that no one business "owns" them. Rotation programs are effective at dispelling this concept. Also, these key people should be brought together periodically to trade notes and to explore cross-organization opportunities.

The feeling of overall community must be fostered. The SBU is a way of proceeding once direction has been decided. The SBU is not good for the developing of future products or corporate direction.

Services-Based Strategy

In the past forty years, the global economy has shifted from a manufacturing to a service base, with manufacturing becoming only a small, but significant, part of the overall economy. The shift has been so significant that economists like Quinn, Doorley and Paquette (Harvard Business Review, 1990) advise every organization to think of itself as a service organization, including manufacturing businesses who should now think of goods production as just one more link in a service chain.

With this economic shift comes a corresponding shift in managerial strategy. Instead of building strategies around products, mangers now strategize based on a deep knowledge of a few highly developed core services. They focus on what the company does best, avoid distractions, and leverage their organizational and financial resources far beyond what traditional strategies would allow.

Shifting Strategic Focus

In older manufacturing economies, the vertical integration model was prevalent. One company would own all the processes necessary to bring a product to market, including the research and development, manufacturing, distribution, etc. Conventional management strategy during this period involved reverse engineering a competitor's products and then cloning them more efficiently or improving upon them.

In a service-based economy, that strategy is no longer conventional, nor prudent. Instead, management should concentrate on differentiating itself by identifying those core service activities where it has, or can develop, unique capabilities. Apple's production of computers is a useful example. Apple buys many of its computer's parts (e.g., microprocessors, chips, monitors, power supplies, etc.) from manufacturers who specialize in their production. Instead of manufacturing these parts, Apple focuses its energies on the design and marketing of its computer products, two services at which it excels.

In order to employ this service-based differentiation strategy, management must do the following:

1. Define each activity in the value chain as a service that can be produced internally or sourced externally.

2. Ask the following question: "Do we have or can we achieve best-in-class capabilities for this service?"
3. If the answer is "yes," ask "Should we make it a part of our core strategy?"
4. If the answer is "no," ask "What possibilities exist for outsourcing the activity or forming a strategic alliance with someone who does have superior capability?"
5. Focus the organization's energies on two sets of activities: those where it can create unique products or services and those it must control to maintain its supremacy in the critical elements of its value chain.

Whenever a company produces something internally that others can make more efficiently and effectively, it sacrifices competitive advantage. The key to strategic success has been a carefully developed coalition with one or more of the world's best suppliers, product designers, advertising agencies, financial houses and other service providers.

What Stays and What Goes?

Much of most companies' cost is in overhead (estimated to be two thirds). To remain competitive, management must ask:

- Which costs are associated with core competencies and which can be outsourced for cost advantage?
- Activity by activity, are we the best? Will outsourcing or forming coalitions improve productivity and improve the long-term competitive position?

A few examples:

- American Express handles billing for Master Card. It can do it better and cheaper.
- Seagate supplies disk drives for most computer manufacturers.
- Alliances with noncompeting enterprises can add efficiencies that are not obtainable within an organization.

By avoiding investments in vertical integration, and by managing intellectual systems instead of workers and machines, companies decrease total investment and leverage resources substantially. They also minimize certain unavoidable risks. Also, if an outsourced product is out-performed by a competitor, the company can switch to a supplier which can perform as well as, or better, than the competitor with minimal interruption to its own production. This kind of action reduces concerns about idle capacity and inventory losses.

Summary

Strategy is the method by which an organization uses the resources of its internal environment to meet the needs of customers in the external environment. In order to develop a competitive strategy, management must have a comprehensive knowledge of its internal resources, as well as the organization's customers, competitors and suppliers. It is also important that they be familiar with the strategic models and concepts discussed within this section. This knowledge combined enables management to create an effective, competitive strategy for its organization.

2.4 Partnering and Outsourcing Strategies

In an effort to streamline operations, managers may choose to engage the services of third party service providers. This engagement is referred to as "outsourcing," or, if the provider is off shore, "off-shoring." Outsourced activities may be small, easily defined tasks, like payroll processing, data storage, or disaster recovery; or they may be larger functions like IT, human resources, or manufacturing. These outsourcing relationships are frequently more akin to strategic partnerships than to subcontracts, but the term's origins reflect the fact that the work was seen as moving "outside" the company, or "outsourced."[26]

For many companies, the decision to outsource may be the largest single financial commitment they will make. Effective outsourcing is critical to organizational success. Company goals should not be focused on abdicating responsibility, but should instead strive for finding partners on their path to achieving excellence. Figure 2-17 indicates several reasons a company may benefit from outsourcing.

Why outsource?

- Lower costs (due to economies of scale or lower labor rates)
- Variable capacity
- The ability to focus on core competencies by eliminating peripheral ones
- Lack of in-house resources
- Getting work done more efficiently or effectively
- Increased flexibility to meet changing business and commercial conditions
- Tighter control of budget through predictable costs
- Lower ongoing investment in internal infrastructure
- Access to innovation and thought leadership
- Possible cash influx resulting from transfer of assets to the new provider

Figure 2- 17 Reasons for Outsourcing[27]

2.4.1 Knowledge of Outsourcing and Partnering Resources

According to a Bain & Company survey conducted in 2005, "82% of large firms in Europe, Asia, and North America use outsourcing to service one or more business

[26] "10 Years that Shook IT," *CIO Magazine,* October 1, 1999. Available at http://www.outsourcingprofessional.org/firmbuilder/. Viewed 08/10/09.

[27] Stephanie Overby, "The ABCs of Outsourcing." Available at http://www.cio.com/article/118100/The_ABCs_of_Outsourcing. Viewed 08/10/09.

processes. However, almost half the respondents stated that their outsourcing programs fell short of expectations."[28]

One of the greatest outsourcing challenges organizations face is the decision of what organization to partner with. To make an informed decision a considerable amount of effort is required. Begin by clarifying your objectives and the benefits you hope to obtain from the outsourcing relationship. Transform your needs and priorities into search criteria, and then develop a system to quantify, assess, and track the responses received from potential vendors.

.1 Getting Help With the Outsourcing Decision-Making Process

Often, organizations employ consultants that specialize in outsourcing.. These consultants can assist with:

- Assessing your potential outsourcing needs
- Defining requirements and priorities
- Selecting a vendor (e.g., overseeing the Request For Proposal (RFP) process, evaluating responses, performing due diligence, etc.)

Organizations must carefully research consultants' expertise and perspectives. Some advisors may be inclined to coach companies through the outsourcing process instead of helping the organization first determine whether that is the best option.

Some companies are reluctant to involve internal staff in the process because discussions of outsourcing may generate concerns about labor cutbacks. While this is a valid concern, bringing staff into the decision-making and requirements process earlier leads to more effective vendor choices and to an "openness around the process that goes a long way toward allaying fears."[29]

The International Association for Outsourcing Professionals (IAOP) (http://www.outsourcingprofessional.org/) offers a variety of resources for organizations pursuing outsourcing, including:

- Numerous educational programs.
- The Certified Outsourcing Professional (COP) program to certify individual's knowledge and skills in outsourcing design, implementation, and management
- Firmbuilder.com®, a database of outsourcing providers.[30]

---

[28] "The Search for Outsourcing Truths" *BPO Journal,* April 09, 2006. Available at http://bponews.blogspot.com/. Viewed 08/10/09.

[29] Stephanie Overby, "The ABCs of Outsourcing." Available at http://www.cio.com/article/118100/The_ABCs_of_Outsourcing. Viewed 08/10/09.

[30] International Association for Outsourcing Professionals (IAOP). Available at http://www.outsourcingprofessional.org. Viewed 08/10/09.

The Association of Strategic Alliance Professionals (ASAP) (http://www.strategic-alliances.org/) is another resource for outsourcing decision-makers.[31] Its mission is to provide its members with:

- Information on opportunities for strategic alliances
- Best practices in the management of strategic alliances
- Awareness of the unique professional discipline of strategic alliance management and its contribution to both individual companies and the field of management.[32]

Putting It Into Practice: What resources have you used to help you with an outsourcing decision-making process? How were they helpful to you? What potential problems could you foresee when a manager does not seek out professional assistance?

2.4.2 Knowledge of Company Business and Strategic Plans

Outsourcing failures are far more likely to occur when organizations rush to implement a "quick fix" to their challenges and neglect to align their activities to the company's longer term planning activities. Rarely successful as a cost cutting measure, outsourcing is best seen as an investment.

In order to avoid potentially catastrophic results, and to best leverage an organization's resources, outsourcing must be aligned with a company's strategic plan. The following strategy planning activities will help identify the functions best suited for outsourcing:

- Assessments of company goals, strengths, and markets
- Identification of gaps in current product/service lines
- Description of customer needs and market trends
- Determination of transformation strategies (restructuring, TQM, etc.)
- Identification of core competencies that should be kept in-house rather than outsourced[33]

Three types of outsourcing strategies are tactical, strategic, and transformational.

- **Tactical outsourcing:** In this approach, the decision to outsource is directly tied to an immediate organizational challenge. The tactical relationship may be forged to create immediate cost savings, to eliminate the need for future investments, to realize a cash infusion from the sale of assets, or to relieve the burden of staffing. When successful, these relationships maximize the use of capital investment and management time. Note, this is an older approach to outsourcing, but is still in use.
- **Strategic outsourcing:** When companies saw the benefits gained from the tactical outsourcing of payroll functions, etc., managers realized that their time was released to address more strategic issues. Strategic outsourcing relationships are distinct in that the

[31] Association of Strategic Alliance Professionals (ASAP). Available at http://www.strategic-alliances.org/. Viewed 08/10/09.

[32] ibid.

[33] Outsourcing Survival. Available at http://www.edular.com. 08/10/09.

relationship with the service provider is more of a partnership that creates long term value than a short term "buyer and seller" arrangement.

Strategic outsourcing focuses on identifying a company's core competencies and then partnering with a provider to deliver on non-core activities. This allows the company to focus its resources on its core competencies. For example, Kodak outsourced its IT functions to IBM so that it could better focus its efforts on other strategic business priorities. This occurred when leadership at Kodak noted that their mission statement did not declare that they would be a leader in computing.

Strategic outsourcing is also a means for companies to streamline operations. By selecting vendors who are considered "best in class" integrated service providers (rather than smaller single service vendors), management time is often reduced because supervisory requirements are reduced.

- **Transformational outsourcing:** This approach, also described as "third generation outsourcing," involves partnering with another company to achieve a rapid, substantial, and sustainable improvement in an organization's performance or mission. In this instance, outsourcing is seen as a powerful tool for innovation and a force for organizational change. It helps organizations to "redefine the world before it redefines them."[34]

Putting Outsourcing Into Practice: What do you see as the benefits of Strategic outsourcing? What would be the benefits, if any, to transformational outsourcing at your company?

2.4.3 How to Establish Outsourcing Relationships

Any manager involved in outsourcing would admit that the process is difficult. Experts place the failure rate of outsourcing relationships at anywhere from 40 to 70 percent.

An obvious challenge is the fact that there is an inherent conflict of interest in any outsourcing arrangement. Outsourcing services providers are in business to make a profit, and the outsourcing "customer's" goal is to receive high-quality service — often hoping for lower costs than if the work were done internally. For the relationship between customer and provider to be effective, the needs of both organizations must be carefully managed and met.

Naturally, some outsourcing projects will find success easier to achieve than others. MIT's Center for Information Systems Research discovered that:

> "Transactional outsourcing deals, in which a company outsources discrete processes that have well-defined business rules, are successful a whopping 90 percent of the time. Co-sourcing alliances, in which client and vendor jointly manage projects (usually application development or maintenance work that goes offshore) are successful only

[34] "10 Years that Shook IT, CIO Magazine, October 1, 1999. Available at http://www.outsourcingprofessional.org/firmbuilder/. Viewed 08/10/09.

63 percent of the time... Generally speaking, risks increase as the boundaries between client and vendor responsibilities blur and the scope of responsibilities expands."[35]

.1 Outsourcing Activities Stages

Outsourcing activities proceed through nine stages (Figure 2-18).

Outsourcing Stage	Activity
1 Strategy	Upper management's assessment of goals and needs
2 Reassessment	Re-examination of the decision to outsource
3 Selection	Process for pursuing and selecting vendors
4 Negotiation	Agreement on terms and conditions
5 Execution	Transition phase, including early planning and execution
6 Oversight management	All ongoing program management activities
7 Build completion	Program "completion" — introduction to and acceptance of new services
8 Change	Responding to any modification that need to be made
9 Exit	The end of the arrangement

Figure 2- 18 The Nine Stages of Outsourcing Activity[36]

Recommendations:

- Because the "culture" of the outsourcing partner organization may dramatically impact the organization, be careful of a good fit — especially if planning a long-term relationship.
- Consider service providers who are established industry leaders and who have a proven track record of success. Do not assume, however, that they are the only trustworthy options. Many smaller vendors exist with excellent capabilities and services.
- Determine organizational priorities (e.g, Are costs or pricing the primary concern? Which is more effective: vendors with a wide or targeted array of services? etc.).
- Develop and implement an evaluation process that enables the organization to weigh the advantages and disadvantages carefully, and at a very specific level
- Avoid allowing contract negotiations to become adversarial.
- Keep lines of communication open and act quickly on concerns. Do not let the relationship devolve to the level where actions are pursued in court.

.2 Developing Outsourcing Relationships

There are additional issues to address when formulating outsourcing relationships (see Figure 2-19). Take these into consideration when developing outsourcing partnerships.

---

[35] Stephanie Overby, "The ABCs of Outsourcing." Available at http://www.cio.com/article/118100/The_ABCs_of_Outsourcing. Viewed 08/10/09.

[36] "The Outsourcing Life-Cycle — 9 Stages." Available at http://www.outsourcingprofessional.org/firmbuilder/articles/34/200/945/. Viewed 08/10/09.

Outsourcing Relationship Considerations
• Pricing • Length of contract • Number of vendors to engage • Hidden costs of outsourcing • Location of outsourcing – overseas or local • Preparing for the transition period • Options if the partnership doesn't work

Figure 2- 19 Outsourcing Relationship Issues[37]

.3 Pricing Considerations

The best pricing arrangements meet the needs of both organizations. Refer to Figure 2-20 for the range of pricing options.

Pricing Options	
Unit pricing	Payment based on usage of a service. A flexible option.
Fixed pricing	The customer pays a flat rate for services no matter what. Attractive because costs are predictable.
Variable pricing	A fixed price at the low end of a supplier's provided service with allowance for varied prices if differing services are provided.
Cost-plus	Customer pays for provider costs, plus percentage that becomes supplier's profit. Disadvantage is that this has no incentive for the vendor to improve their service delivery.
Performance-based pricing	Includes incentives for vendor to improve their performance and often has penalties for unsatisfactory service levels.
Risk/reward sharing	Customer and supplier share risks and profits.

Figure 2- 20 Outsourcing Pricing Options[38]

Length of contract: The length of an outsourcing contracts depends on what's being outsourced and why. For the most part, two to three years is considered too long, unless the contract includes provisions that give both parties flexibility.

Number of vendors to engage: While having one vendor can streamline management efforts, it minimizes the potential benefits of having healthy competition among vendors.

[37] Stephanie Overby, "The ABCs of Outsourcing." Available at http://www.cio.com/article/118100/The_ABCs_of_Outsourcing. Viewed 08/10/09.

[38] ibid.

With multiple service providers, the challenge--especially for smaller organizations--is supervision (e.g., monitoring performance, maintaining effective relationships, and managing inter-vendor relationships, etc.).

Hidden costs of outsourcing: Remember, the dollar figure quoted on an outsourcing agreement does not represent the total cost of the outsourcing engagement. Current data shows that the administrative costs associated with managing outsourced activities can add an additional 10% to 65% of the total. These administrative costs include the expense of strategic analysis, data collection, advisory assistance, transition expenses, layoffs, and associated HR activities. For offshore sourcing arrangements, there is also the cost of additional advisory consulting, travel, and the various other expenses incurred when working with differing business practice/cultures. Be mindful, too, of currency conversion when working with an offshore sourcing partner.

Preparing for the transition period: When outsourcing, bear in mind that the most challenging part of the process is frequently in the initial engagement. It takes time for all involved parties to familiarize themselves with each other and their products, services, processes, resources, expectations, organizational culture, etc.

Options if the partnership doesn't work: Backing away from outsourcing is rarely easy — hence the emphasis on being sure the relationship is not entered into lightly. Usually, the best option is to renegotiate.

Putting It Into Practice: Imagine that you are developing an outsourcing contract at your company. Assess your current outsourcing skills and knowledge. In which steps of the process do you need the most development?

2.4.4 Establishing Partnering Relationships

Partnering relationships—referred to as "strategic alliances" or "partnerships"—may be joint ventures, or occasionally acquisitions. All partnerships except for acquisitions are similar to outsourcing relationships. What would have been addressed through outsourcing may now be done through partnering. Vendor and provider interactions are less and less adversarial and increasingly focused on long-term partnerships between equals, where the emphasis is on mutual benefit. In fact, some experts view strategic partnerships and alliances simply as more sophisticated outsourcing agreements. "Where once firms kept outsourcing in the background, never letting their customers know part of the work was delivered by a third party, now firms cobrand products/services and firms march out their outsourcing providers to instill confidence in customers and business partners."[39]

.1 Why Enter Into Partnering Relationships?

- More customers
- Additional capital

[39] "10 Years That Shook IT," *CIO Magazine,* October 1, 1999. Available at http://www.outsourcingprofessional.org/firmbuilder/. Viewed 08/10/09.

- New or additional distribution channels
- Pre-existing relationships or old-fashioned clout
- Experience with a new business model
- Agility and innovation
- New products or services
- Specialized knowledge, expertise, or experience
- Low-cost or unique production capacity[40]

.2 Competitors Can Be Partners

Strategic alliances may be formed with competitors in order to ally against a common foe. When entering into such an alliance, keep the following in mind:

- Be clear about objectives (e.g., gaining new knowledge and skills, service/product/technology gaps, avoiding capital investment, improving supply chain, reducing time to market, regaining competitiveness quickly with minimal effort).
- Never forget that competitor partners are still competitors.
- Challenging to maintain a win-win as opposed to a dominant partner superseding their partner.
- Conflict is healthy — a good sign that collaboration is mutually beneficial.
- Information exchange is part of the benefit for both organizations. The challenge is to ensure that staff know parameters for what is not to be shared (undesired information leaks — usually done intentionally by lower level staff.

Putting It Into Practice: What competitors would you like to partner with? Why? How would you approach them? How and when do you discuss the financial and liability issues?

Whether or not the partnership is with a competitor, also remember to:

- Protect key product values
- Secure essential access strengths
- Hold on to vital operating abilities
- Safeguard critical technologies
- Preserve growth options
- Maintain a strong organization
- Sustain financial strengths
- Plan for unreliable relationships
- Consider the pros and cons of exclusivity[41]

[40] The Corporate Partnering Institute. Available at http://www.corporate-partnering.com/cpi/. Viewed 08/10/09.
[41] Jordan D. Lewis, *Partnerships for Profit: Structuring and Managing Strategic Alliances*, The Free Press (A Division of Simon and Schuster), NY, 1990, pp. 49-66.

2.5 Financial Risk Management Strategies and Models for New Technologies

Risk exists because of uncertainty, and uncertainty exists because of change. For organizations this means the risk of change in their market position is the result of a variety of internal and external factors. For engineers to assess risk, they must assess the potential impact of changes — change drivers (see Figure 2-21). Change drivers, in turn, are simply events or variables.

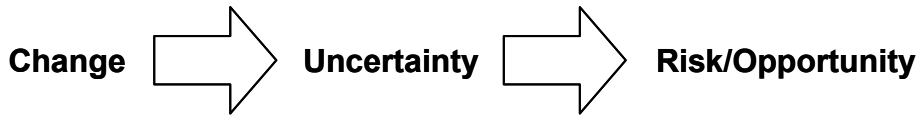

Figure 2- 21 Change Drivers

In order to identify risks, companies should employ a variety of methods. A survey conducted by the Academy of Competitive Intelligence revealed that many companies still use nonsystematic approaches to identifying risk (see Figure 2-22).

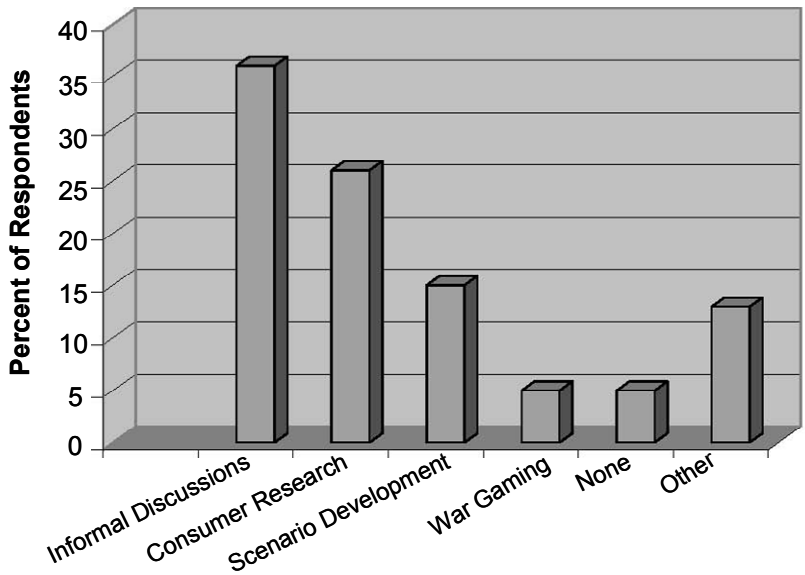

Figure 2- 22 Risk Identification Methods[42]

With the ever-increasing number of diagnostic tools available, it is surprising that few companies take advantage them.

[42] Early Warning *by Ben Gilad. Copyright 2004 by AMACOM Books. Reproduced with permission of AMACOM Books via Copyright Clearance Center.*

2.5.1 Knowledge of Techniques, Strategies, and Models

There are a number of risk analysis techniques and models available for engineers to use. Your selection of technique should be guided by the complexity of the project at hand; complex projects demand complex risk analysis tools, while simpler tasks require more straightforward models. Using the risk analysis techniques most appropriate to the complexity of your project will reduce the opportunity for error. Readers are asked to refer to the "For Further Information" section at the end of this domain for additional detail on risk analysis techniques.

.1 Cost Analysis

Simple cost-based decision models include comparison of alternatives and replacement evaluations.

Product cost estimating can be challenging for engineers because, while some costs are well defined and firm, others are "soft dollar credits." In order to overcome potential difficulties, risk analysis should:

- Explicitly define the uncertainty of input variables
- Allow for reasoned estimating procedures
- Provide the opportunity for more comprehensive analysis
- Quantify the variability of output variables

.2 Sensitivity Analysis

When assessing the sensitivity of the project as it is affected by cost, time, and completion, "what if" analyses are usually performed due to possible variation of specific input parameters.

.3 Contingency Cost Estimation

Contingency costs are often used when estimating a risky project. Typically, five to seven percent of the task cost is added to each task to provide an allowance for the risk involved. Decision trees are frequently used to evaluate sequential decisions and to develop the best alternative based on the anticipated values of the probable outcomes.

.4 Diversification

Diversification can be used to achieve a reasonable overall return on investment when project risks are high. Combining high-risk, high-return projects with low-risk, low-return projects when engaging several risky projects at the same time provides the diversification needed to distribute the risks.

.5 Fuzzy Logic Systems

Fuzzy logic systems utilize fuzzy sets that use limits to define ranges of values that represent concepts. Values for degrees of membership are also developed by the user. A value of one will indicate full membership, and zero indicates exclusion. For ease of use, the change of membership from zero to one is gradual.[43]

2.5.2 How to Perform an Analysis to Assess the Financial Risks of Introducing New Technology Into Various Markets

.1 Change Drivers

Industry change drivers are events or variables that drive the evolution of industries. Watching these carefully will better position you to assess the risks involved with introducing a new technology into the market place.

Changes drivers differ among industries, but may include:

- A new technology or science
- New regulations or other governmental/political action
- Financial changes in global or local economies
- New social/demographic trends
- New competitive behaviors[44]

.2 Interpreting and Applying Results of Risk Analysis

Scenarios are considered the most powerful risk analysis tools. They are formulated by creating hypotheses about what will happen in the future, based on the input of different sets of variables. Scenarios can be used singly or as part of a set, showing a variety of situations that decision makers can use to evaluate their options. Three common risk analysis approaches are:

- Simulations
- Delphi methods
- Impact matrix

Project cost estimation by simulation:

- Develop a cost model for the project using a standard spreadsheet program
- Make a three–point estimate for each of the component costs identified
- Implement risk analysis software, using the data collected in the spreadsheet

---

[43] C. M. Chang, *Engineering Management: Challenges in the New Millennium*, Pearson Prentice Hall, Upper Saddle River, NJ, 2005, p. 161.

[44] Benjamin Gilad, *Early Warning: Using Competitive Intelligence to Anticipate Market Shifts, Control Risk, and Create Powerful Strategies*, AMACOM Books, New York, NY, 2004, p. 72.

- Conduct a Monte Carlo simulation to compute total project cost
- Interpret the total project cost[45]

Results will vary, but will typically include the following:

- There is an 80 % probability that the cost will not exceed $D
- The minimum, most likely, and maximum total project costs are $A, $B and $C
- The standard deviation of the total project cost is "x", or the overall measure of the project risk[46]

Organizations can use scenarios in a variety of ways. They can select a preferred scenario and formulate and implement plans base on that scenario. Or, organizations may use what are called robust strategies — strategies that take into consideration a variety of scenarios and attempt to plan and allow for a set of the contingencies indicated in the group of scenarios.

Experts differ on the best scenarios process to use. The challenge often is to find a risk analysis scenario that works within the organizational or department constraints (time, budget, staffing resources, etc.).

The Delphi method — estimating probabilities using subjective systems:
Determining risk-related probabilities is a difficult task. In some cases, more subjective approaches can produce meaningful and useful results. The Delphi method is a process for eliciting information from a panel of experts, using questionnaires and tolls that will enable researchers to control opinion feedback. It is very useful when the aim is to develop a "group judgment." For more information on the Delphi method, see Section 1.4.1.

Impact matrix: There are several variations of impact matrices. The impact matrix below (Figure 2-23) compares "potential impact" to "uncertainty." Matrices are useful when comparing several different scenarios. Scenarios that fall into the upper right quadrant, "Uncertain and High Impact," should be followed closely.[47]

[45] C. M. Chang, *Engineering Management: Challenges in the New Millennium*, Pearson Prentice Hall, Upper Saddle River, NJ, 2005, pp. 153-155.

[46] ibid., p. 155.

[47] Benjamin Gilad, *Early Warning: Using Competitive Intelligence to Anticipate Market Shifts, Control Risk, and Create Powerful Strategies*, AMACOM Books, New York, NY, 2004, p. 82.

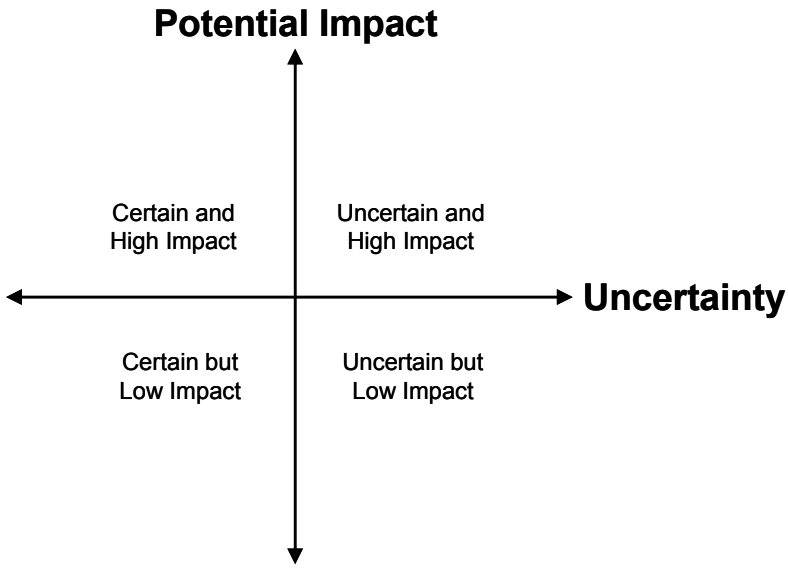

Figure 2- 23 Impact Matrix

Also of concern when conducting financial risk assessment for new technology introduction is the difference that is too frequently found between the market conditions and the existing company strategy (marketing, R&D, use of capital, etc.). If a distinct difference exists between the proposed new technology and the stated or practical business strategy, these differences will need to be addressed.

.3 Getting Management to Act

Once risk has been assessed and evaluated, the next challenge becomes implementing action plans. The engineering team must find a way to communicate effectively with higher levels of management and elicit their commitment. Figure 2-24 below represents a vision of the process of transforming risk identification to management action.

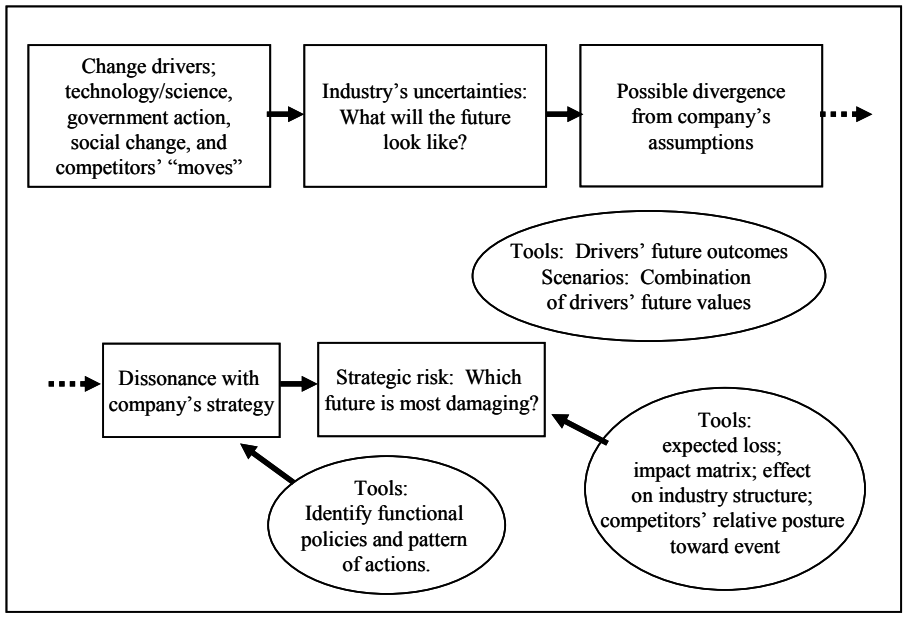

Figure 2- 24 Identification and Prioritization of Risks.[48]

2.6 Change Management Techniques and Adjustment Strategies

Change is as inevitable in business as it is in life. Effectively managing it is key to the smooth, orderly functioning of your operation.

To successfully manage change, all management levels must visibly commit to and lead the change process. Some characteristics of a change leader include:

- Understanding business
- Understanding the dynamics of organizational change
- Possessing the respect and trust of coworkers
- Having the ability to
  - Multitask
  - Simplify complex issues
  - Handle uncertainty
  - Manage conflict well

2.6.1 Knowledge of Change Process Dynamics

One of the world's most successful community organizers, A.T. Ariyarante described the change process this way: "When we try to bring about change in our societies, we are treated

[48] ibid., p. 86. Diagram Reproduced with permission of AMACOM Books via Copyright Clearance Center.

first with indifference, then with ridicule, then with abuse and then with oppression. And finally, the greatest challenge is thrown at us: We are treated with respect. This is the most dangerous stage."[49]

.1 Rules of Change

Change usually does not happen overnight. In order to create an environment where change can occur in an orderly fashion, several guidelines must be acknowledged and addressed.

- Change cannot be mandated
- Change is non-linear
- Change occurs on several levels simultaneously
- Change does not occur without problems
- Change can be blinded by premature vision and planning
- There are no one-sided solutions — individualism and collectivism must occur in tandem
- Effective change does not occur in either a centralized or decentralized organization. Change occurs best simultaneously from a top-down *AND* bottom-up strategy.
- Interaction with the wider environment is necessary for change
- Every person is a change agent
- Leadership commitment is vital for success

.2 Conflict

Conflict is a part of the change process. Conflict can be either functional or dysfunctional. The change leader must strive to maintain functional conflict with the group.

The following chart (Figure 2-25) depicts the functional and dysfunctional aspects of conflict.

Functional Conflict	Dysfunctional Conflict
Increases/strengthens team mentality	Prohibits team from
Increases cohesion	completing task
Improves communication	Is personally destructive
Produces effective ways of operating	Lowers quality of decisions
Contributes to better quality	Threatens team's survival

Figure 2- 25 Functional and Dysfunctional Conflicts

[49] A. T. Ariyarante, Speech made at Community Leadership Summit, Winrock, Arkansas, March 1983.

2.6.2 Knowledge of Factors Contributing to Resistance to Change

To better manage change, it's important to understand why many individual and organizations are likely to resist it. Common reasons for change resistance include:

- Lack of clarity in stating the problem — if the problem cannot be described, it's difficult to get others to believe it exists
- Not getting the required information
- Poor communication within the team
- Premature testing of alternative strategies
- A critical, evaluative, competitive climate — an open, positive, environment facilitates change by allowing communication to occur
- Pressures for conformity
- Lack of problem-solving skills
- Inadequate motivation
- Group think — the more ingrained and successful an activity is from a management and engineering point of view, the more difficult it is to question and change.

Even with a majority acceptance of change, there will still be those individuals who resist. The following model depicts some of the decisions made by employees to actively resist change.

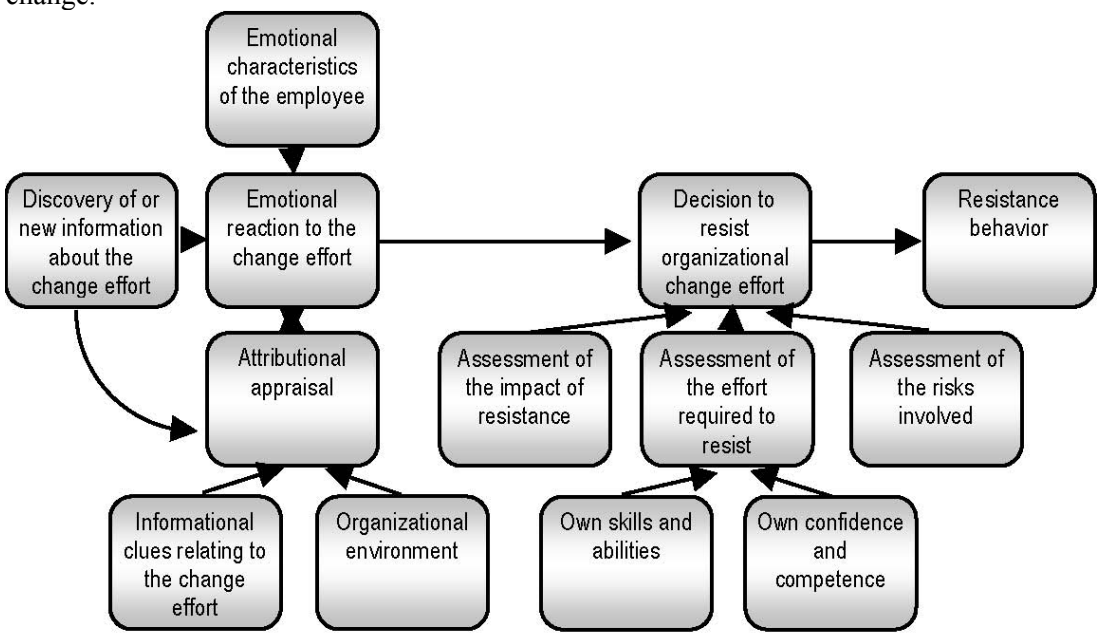

Figure 2- 26 Model of the Employee Decision to Actively Resist an Organizational Change Effort[50]

[50] Phil Hay and Charmaine E. J. Hartel, "Toward Improving the Success of Change Management Efforts: Modeling the Factors Contributing to Employee Resistance During Change Implementation in Management

2.6.3 How to Implement Change Effectively in a Group or Team

.1 High Performance Team Characteristics

Team dynamics play a critical role in the ability to implement change. The characteristics necessary for the existence of high-performance teams include, but are not limited to :

- Good leadership
- Fluid leadership that makes the most of each member's strengths
- Open communication
- Clearly defined team goals
- Clearly defined roles for each team member
- Support from upper management
- Recognition of the unique contributions of each team member
- Personal satisfaction derived from team activity
- Shared experience
- Comfortable honesty between team members
- Diverse talent and personality
- Desire for excellence
- Ability to disagree
- Passion for mutual success
- Willingness to share responsibility
- Mutual respect and trust
- Humor — performance with fun

.2 Facilitating Change Through Assessing Team Performance

High-performing teams are dynamic, successful groups of individuals who are highly task- and people-oriented. They are characterized by high morale, an emphasis on achievement, and a genuine willingness to solve problems.

Use the guidelines below to evaluate a team's performance levels. For teams that are not yet high performers, use these guidelines to help identify opportunities for improvement.[51]

- **Participation:** Look for differences in the amount of participation among members.
  - Who are the high participators?
  - Who are the low participators?
  - Is there any shift in participation; e.g., highs become quiet, lows suddenly become talkative? What possible reasons are there for this in the group's interaction?

Development Forum," **3,** no. 1, Empire State College, Saratoga Springs, NY, 2000. *Figure used with permission of the Empire State College Management Development Forum.*

[51] J. William Pfeiffer, and Jim E. Jones, eds., *The 1972 Annual Handbook For Group Facilitators*, University Associates, Inc., LaJolla, CA, 1972.

- How are the quieter team members treated? How is their silence interpreted?
- Who talks to whom?
- Who keeps the ball rolling?

- **Influence: Influence and participation are not the same.**
  - Which members are high in influence — when they talk, others seem to listen?
  - Which members are low in influence — others do not listen to or follow them? Is there any shifting in influence? Who shifts?
  - Are there any rivalries within the group? Is there a struggle for leadership? What effect does it have on other group members?

- **Styles of Influence:** Influence can be positive or negative; it can enlist the support or cooperation of others or alienate them.
  - Autocratic — Does anyone attempt to impose his will or values on other group members?
  - Peacemaker — Does anyone consistently try to avoid conflict or unpleasant feeling from being expressed? Do any members appear to avoid giving negative feedback?
  - Laissez-Faire — Are any group members getting attention by their apparent lack of involvement? Does any group member go along with group decisions without seeming to commit himself one way or the other?
  - Democratic — Does anyone try to include everyone in a group decision or discussion? When feelings run high and tension mounts, which members attempt to deal with the conflicts in a problem-solving way?

- **Decision-Making Procedures:** Many kinds of decisions are made in groups without considering the effects of these decisions on other members.
  - Does anyone make a decision and carry it out without checking with other group members?
  - Does the group drift from topic to topic?
  - Who supports other members' suggestions or decisions?
  - Is there any evidence of a majority pushing a decision through over other members' objections? Do they call for a vote?
  - Is there any attempt to achieve consensus — getting all members to participate in a decision?

- **Task Functions:** These functions illustrate behaviors used to accomplish the task the group has before them.
  - Does anyone ask for or make suggestions regarding the best way to proceed?
  - Does anyone attempt to summarize?
  - Who keeps the group on target?

- **Maintenance Functions:** These functions are important to the morale of the group.
  - Who helps others get into the discussion?
  - Who cuts off others or interrupts them?
  - How well are members getting their ideas across?
  - How are ideas rejected? Do members support others when they reject their ideas?

- **Group Atmosphere:** Are the realities of the situation acknowledged and understood?
  - Is there any attempt to suppress conflict or unpleasant feelings?
  - Do any members provoke or annoy others?
  - Do people seem involved and interested?

- **Membership:** The degree of acceptance or inclusion in the group.
  - Is there any sub-grouping?
  - Do some members appear to be "outside" the group? How are they treated?
  - Do some members move in and out of the group? Under what conditions do they come in or move out?

- **Feelings:** Are the feelings of group members observable?
  - What signs of feelings are observable in group members — anger, frustration, warmth, affection, excitement, competitiveness?
  - Are there any attempts by group members to block the expression of feelings?

- **Norms:** The "rules" of the group.
  - Are certain topics avoided by the group? Who seems to enforce this avoidance?
  - Are members overly nice or polite to each other?
  - Do questions tend to be restricted to intellectual topics or events outside the group?

Note: It is almost impossible to participate in a team while evaluating the same team. An impartial third party is often the best assessor — offer to evaluate another team in exchange for their evaluation of your team.

Once improvement opportunities have been identified, you can develop strategies to address them. A variety of tools and techniques for improving team performance are provided in *The Fifth Discipline Fieldbook: Strategies and Tools for Building a Learning Organization.*[52]

As change occurs, individuals are often forced to move outside their comfort zone. To address this, change management programs should achieve buy-in from all, or at least a healthy majority, of those involved in the change. It's also crucial the change program explicitly address staff concerns, communicate the rationale behind the change, and clearly state the intended results. To create a sense of enthusiasm and success around the change program, you might also want to offer rewards for the successful implementation of the change.

[52] Peter Senge, *The Fifth Discipline Field Book Strategies and Tools For Building a Learning Organization*, New York, NY, 1994.

REVIEW

Upon completing the study of *Domain 2: Strategic Planning and Change Management,* you will be able to answer the following questions:

1. Describe each of the four strategic planning methods discussed in the chapter. What are the purposes and advantages of each?
2. What is a CIP? Discuss the information-gathering methods used to perform a CIP, as well as the methods used for interpreting the results.
3. Identify five system design tools and describe the characteristics of each.
4. Why is life-cycle engineering so important? What are the five stages of a project's life cycle?
5. Discuss at least two resources that are helpful when initiating an outsourcing relationship. Detail the benefits of each resource.
6. Create a list of at least 10 "tips" or ideas that you will keep in mind when working with vendors in an outsourcing relationship.
7. What are the differences between functional and dysfunctional conflict?
8. Discuss at least six reasons why people resist change and what it is you can do to overcome that resistance.
9. What can organizations do to facilitate acceptance of change? Discuss at least five actions.
10. What results can you expect from cost analysis of risk processes? Describe at least two alternative methods you can use.
11. Discuss simulations . Why are they useful risk analysis tools?

Domain 3: Product, Service and Process Development

Domain Champion: Hiral Shah, Ph.D.

3.1 Engineering Disciplines

- 3.1.1 Knowledge of appropriate engineering disciplines
- 3.1.2 Applying engineering disciplines to interpret research and development results
- 3.1.3 Applying engineering technologies to develop products and processes or evaluate alternatives

3.2 Manufacturability

- 3.2.1 Knowledge of pilot production and feedback process
- 3.2.2 Knowledge of product feasibility, planning, and development tools
- 3.2.3 Knowledge of design for manufacturing and assembly/disassembly procedures
- 3.2.4 Knowledge of Kaizan and Lean production techniques
- 3.2.5 Knowledge of quality analysis techniques such as TQM and Six Sigma
- 3.2.6 Knowledge of simulation models and applications
- 3.2.7 Knowledge of Computer-Driven Software Systems That Can Translate Customer Information Into Product Design Requirements
- 3.2.8 Knowledge of techniques to design experiments
- 3.2.9 Applying the tools and techniques to evaluate the manufacturability of one product or alternative products considering technical and practicality factors

3.3 System Design Methodology and Life Cycle Engineering Product/Process Creation (Product or Service Specifications)

- 3.3.1 Knowledge of integrated product design and development methods
- 3.3.2 Knowledge of life cycle engineering analysis
- 3.3.3 Knowledge of factors that influence product creation such as design for environment, design for maintenance, design for re-usability, design for service, design for disposal, and design for life cycle analysis (design for “X”)
- 3.3.4 Knowledge of cost analysis techniques
- 3.3.5 Knowledge of simulation models
- 3.3.6 Knowledge of web-based product design tools
- 3.3.7 Applying techniques to design products, services, and processes from a total system and life cycle engineering perspective

Domain 3: Product, Service and Process Development

Key Words and Concepts

Black Belt	Person who leads a Six Sigma quality improvement team as his or her full-time job.
DMAIC	Quality strategy that is part of the Six Sigma quality initiative. Stands for "Define, Measure, Analyze, Improve and Control."
Green Belt	Person who assists Black Belts as a part of Six Sigma process improvement team.
Kaizan (Kaizen or Kaizenshiro)	Gradual, unending process of improvement accompanied by increasingly higher standards.
Lean Manufacturing	An initiative that focuses on eliminating all waste in a manufacturing process.
Poke-a-Yoke	Mistake proofing or error proofing a process
Six Sigma	Tool used to improve business processes. It is characterized by well-defined projects executed by a team that includes management champions, Black Belts, and Green Belts.
Total Quality Management	A management approach to long-term quality improvement that includes the entire organization in the improvement process.

3.1 Engineering Disciplines

To keep pace with technology's increasing complexity, the field of engineering has grown to include a wide range of engineering sub disciplines, each representing a specific area of engineering expertise. Most contemporary technology projects require input from a variety of these disciplines. Few, if any, projects are strictly within the realm of one area of engineering knowledge.

3.1.1 Knowledge of Appropriate Engineering Disciplines

To complete project design and implementation, a project manager must be able to work with a team of engineers that collectively encompasses a broad spectrum of engineering knowledge. In all likelihood, the project manager will need input on materials selection, electronics, tool design, manufacturability, process development, software requirements, and product and process safety. For specialized technology projects, the manager may also require the expertise of engineers capable of developing entirely new materials.

No one engineering discipline can operate autonomously. All are interrelated, and all must be consulted to develop the best solution to the project at hand. The checks and balances provided by a well functioning, multifaceted engineering team ensures optimum use of resources. The "best" design is useless if it cannot be implemented.

Construction engineers, for example, guarantee that a project design can actually be built. The process engineer helps define the sequence of events required to complete a defined group of tasks. The mechanical engineer develops the tools required to create parts, as well as identifies areas for improvement. Computer and software engineers evaluate the project's needs and assist with testing. Chemical and ceramic engineers provide input when special materials are involved. The industrial engineer and the safety engineer determine how best to complete the assigned task both safely and efficiently. Environmental engineers decide which of several alternatives will be most environmentally responsible.

Engineering disciplines have expanded from the land surveyor/road construction role to encompass a multitude of disciplines, each with its own sub-specialties, including:

- Aeronautical
- Biomedical
- Electrical
- Industrial
- Nuclear
- Naval architecture
- Agricultural
- Chemical
- Forest
- Instrumentation
- Mechanical
- Physics

- Architectural
- Civil
- Geological
- Marine
- Mining and metallurgical
- Survey

Engineering disciplines may also be divided by function (e.g., design, operation, management, development, and construction). There are no clear-cut boundaries between disciplines; in fact, a tremendous amount of knowledge is shared among them.

3.1.2 Applying Engineering Disciplines to Interpret Research and Development Results

Many engineers in the workforce today are the product of an older engineering curriculum, one that focused exclusively on the mathematical, physical, and technological requirements of the discipline. It's only the last few years that "soft skills" classes have become a required part of the curriculum. Today's engineering managers, however, know that communication and team-building skills are vital to their success.

.1 Engineering Teams

The engineering manager will often work with teams consisting of experts from a variety of engineering disciplines. Unfortunately, many of these are likely to consider their input to be the most important part of the project. The task of the engineering manager, then, must be to harness the technological expertise of each individual while simultaneously creating a high-performing team that puts egos aside and values the input of each member.

In order to interpret research and development results effectively, a development team must be cognizant of all facets of the project. To do this, the team solicits, evaluates, and utilizes input from all disciplines. A new project design, for example, might seem like the most exciting design ever; but if the design does not take into account the capabilities of the tools required to actually build it, the "exciting design" will remain just a design until the technology to create it is developed.

.2 Evaluation Criteria

In order to interpret research and development results, teams develop evaluation criteria that address all facets of the project, including:

- Use of resources
- Product life cycle
- Manufacturability
- Environmental impact
- Product safety
- Costs
- Return on investment

The project scope is used as the basis for evaluation criteria. Defining the goal and developing the steps to get there helps identify issues the team will address to bring the project to successful completion. Each possible design is then evaluated against the same criteria to determine which best fits the project needs. The team utilizes the expertise of each member by having each one evaluate the portions of the project that are most closely aligned with their knowledge and experience.

3.1.3 Applying New Engineering Technologies to Develop Products and Processes or Evaluate Alternatives

When using new technologies to develop products and processes or to evaluate alternatives, communication between engineering, management, and manufacturing is key. Be sure everyone has the same understanding of the desired end result and issues to be addressed.

.1 New Engineering Technologies

The rapid advances in computer technology have allowed significant changes to the design process. Slide rules and pen-and-ink designers are fading quickly. Today's engineers use:

- CAD (computer aided design) to design a part
- 3D rendering to make it a virtual reality
- Simulation modeling software to identify stresses and manufacturability
- Collaborative design techniques to help mesh the ideas and experience of engineers from around the world into the same project

.2 Design Evaluation

Changes to the product or process generally result in changes to the bottom-line costs associated with the product or process. Computerized simulation models have the ability to identify the effects of changing project variables. As new technologies are implemented, it is often most advantageous to adopt and test each new technology in a pilot or laboratory application prior to instituting a full-scale test. However, when evaluating the results of these controlled processes, it is wise to understand the wide range of variables that will be present when the product or process is released for general use. Under no circumstance assume that the carefully controlled conditions of the lab will bear any resemblance to the actual conditions of use in the "real world."

Each new technology, product, or process will need to be evaluated for:

- Cost
- Feasibility
- Life expectancy
- Environmental impact
- Marketability
- Alternative uses

When evaluating several alternatives, it is best to evaluate each alternative against the same set of criteria. Encourage all project stakeholders to participate in the evaluation.

.3 Process Maps

Process maps, which document the flow of a process, are invaluable in the development and evaluation of new processes (see Figure 3-1 below). By mapping a process flow, you ensure that no critical steps in the process are overlooked.

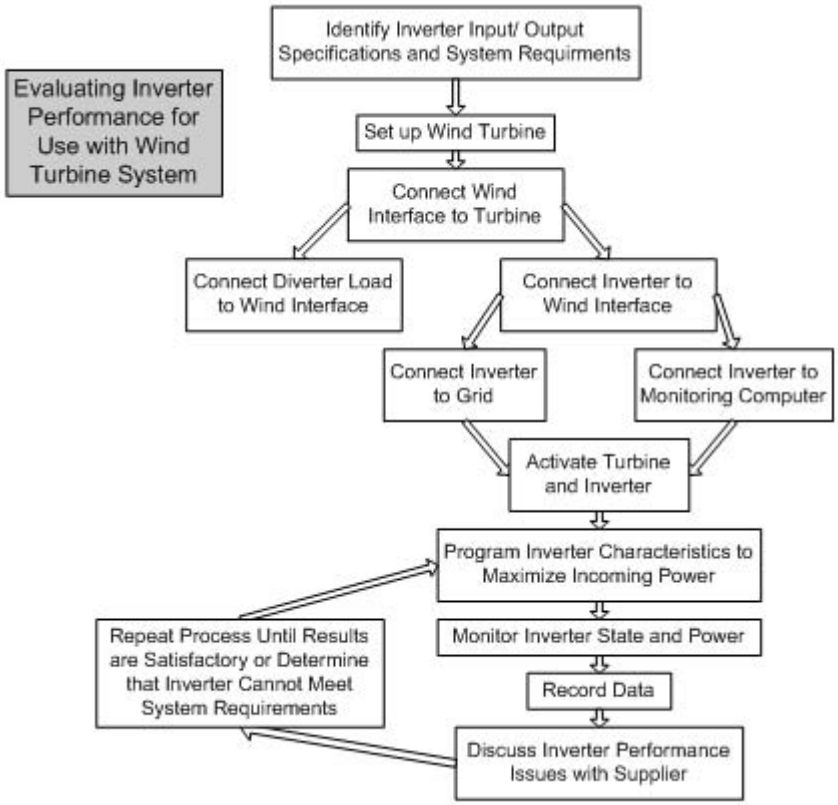

Figure 3- 1 Sample Process Map[53]

Putting It Into Practice: Why it is best for all project stakeholders to be a part of the evaluation of new products or processes?

3.2 Manufacturability

3.2.1 Knowledge of Pilot Production and Feedback Process

Pilot production, while difficult and costly in and of itself, can be used to tweak products and processes to make them more efficient prior to project rollout. Field tests of pilot models often provide the opportunity to identify potential problems and make corrections before a large volume of product has been released to the public.

[53] SAE Total Quality Management Process Map. Available at http://www.sae.org/totalquality/qpm/. Viewed 08/10/09. Figure used with permission of Farell Pelfrey, Pelfrey and Associates, Inc.

.1 Pilot Builds

Design, unfortunately, does not always take into account the physical requirements of the manufacturing environment. Sometimes it is not physically possible to manufacture the product in a safe or efficient manner without the development of special tools and jigs to position and create parts. A pilot build allows manufacturing inefficiencies to surface.

Ideally, feedback from the pilot build should be solicited from all groups involved in the production process, not just engineering. This includes personnel in materials acquisition, scheduling, production operation, safety, tooling, and transportation, as well as anyone else involved in production. Collect feedback from designated representatives from each of these groups on a daily basis, and use it to improve the processes and designs prior to production ramp-up.

It should be noted that feedback received from the production floor is invaluable to the pilot process. The employee who turns the wrench to build the product often has the most practical solution to problems encountered during the pilot build. Be sure to solicit, value, and utilize this person's input. In many instances, machine operators, technicians, etc., have just as much insight as those who hold an engineering degree, and may even possess a greater amount of practical knowledge. Utilize that knowledge base wherever it is found.

.2 Feedback Challenges

Feedback from suppliers, manufacturing personnel, and customers will help in the assessment of any new product pilot. Their combined input will help to ensure the best, most cost-effective product development and implementation. Incorporating the feedback obtained from the individuals involved in a pilot production will help smooth the way for improved performance in the future.

Ideally, the engineers and others involved in the design should be readily available during pilot production, so that they can develop solutions based on field conditions. For global companies, some engineers involved in the design of a product are, in many instances, half a world away from the pilot production facility. Thanks, however, to a wealth of advanced communication tools, web-based design, and increasingly sophisticated simulation utilities, it is now possible for engineering teams almost anywhere on the globe to interact in real time. For those companies that cannot realistically take advantage of such technologies, it is best to have at minimum a representative of the virtual engineering team available on-site to address complications as they arise.

3.2.2 Knowledge of Product Feasibility, Planning, and Development Tools

.1 Product Feasibility Tools

Feasibility issues have signaled the death of many designs. While manufacturing feasibility is an important facet of product design, it is not the only factor that determines a design's feasibility. For example, many designs must be modified to address transportation concerns. Large pressure vessels required for some projects need to be transported to the project site. In the absence of sufficiently deep nearby waterways, these vessels must be constructed for transportation over surface roadways--which significantly impacts their size and configuration--or fabricated and/or assembled on-site.

Similarly, development of a product that does not address or create a customer need is not economically feasible. To avoid this, incorporate input from potential customers into the product development process.

Proper planning and development techniques make it possible for a project team to identify, evaluate, and address many production constraints prior to the finalization of the project plan. This includes identifying issues stemming from raw material availability, issues involved in transporting tools and materials, potential problems in the manufacturing process, final delivery challenges, and end user problems. By identifying and addressing these constraints prior to production, the project team can chart a critical path for project implementation and avoid having manufacturing rollout determine project feasibility.

Also, include representatives from the marketing team in product development activities to ensure that product marketing will be based upon actual product features and capabilities.

.2 Tools

Many project-planning tools are available to assist with the planning process.[54] Several software packages can organize the input from the planning process into a format that is concise and easily understood. Design analysis through computer simulation of the process, process flow simulations, and cost analysis programs will all prove invaluable when assessing project feasibility.

Feasibility assessments can benefit from the use of these tools in the following ways:

- Design analysis through computer simulation of the process allows the designer to ensure that the product, as designed, can be built with the available manufacturing equipment. It will also provide opportunities to improve the design by highlighting process problems before they occur on the production floor.
- Process flow simulations reveal critical paths in the production process. Processes that can be completed in parallel are also identified, so that process flow can be adjusted to eliminate as many bottlenecks as possible.
- Cost analysis tools allow the project team to determine whether production costs of the product, as designed, will be acceptable. It also provides the opportunity to examine the practicality of materials substitution or modifying production methods to reduce costs.

Select project management software that enables all members of the project team to communicate using the same application. The project manager may need to place software training on a meeting agenda in order to ensure that all can contribute equally.

3.2.3 Knowledge of Design for Manufacturing and Assembly/Disassembly Procedures

.1 Design for Manufacturability

Design for manufacturability (see Figure 3-2) is a process to develop products in an efficient and economical manner. The physical capabilities of the manufacturing environment should

[54] For additional information on project-planning tools, see *Guide to Project Management Body of Knowledge*, Project Management Institute (2008).

have a direct impact on the design of the product, as should the assembly and disassembly procedures that accompany manufacturing.

Proactive Design for Manufacturability:	
1. Optimizes all the manufacturing functions:	2. Ensures the best:
• Fabrication • Assembly • Test • Procurement • Shipping • Delivery • Service	• Cost • Quality • Reliability • Regulatory compliance • Safety • Time-to-market • Customer satisfaction

Figure 3- 2 Design for Manufacturability[55]

A new gear design may look good on paper; but if the tool required to cut that gear crashes repeatedly during the hobbing operation, it's probably not the fault of the machine operator. The design may need to be revised. Tool capabilities are a very important consideration during the design of a product. Engineers must understand that the "ultimate" design may not be able to be produced in the manufacturing environment that currently exists, and the design expectations may need to be adjusted to reflect the realities of the manufacturing facility.

When designing for manufacturability, consider:

- Tool capability
- Materials availability
- Worker safety
- Need for retooling
- Product flow throughout the production facility

.2 Assembly/Disassembly Procedures

Assembly/disassembly procedures provide the guidelines, usually in a step-by-¬step format, for each step of the assembly process. Assembly procedures include:

- Parts and tools required
- Order of assembly
- Assembly criteria (such as torque, wait time, temperature requirements, fluid fill levels, etc.)
- Inspection criteria

[55] David M. Anderson, *Design For Manufacturability & Concurrent Engineering,* CIM Press, Cambria, CA, 2004, p. 1.

- Packaging instructions
- Shipping procedures
- Documentation

Review and revise assembly/disassembly procedures to develop a consistent method of product assembly. During the review phase, the project team should carefully evaluate each step of the assembly procedure to fully understand what assembly involves. In an environment where a part cannot be reused due to safety concerns, assembly procedures that require that part to be assembled, then disassembled, then reassembled, require three times the number of that part than the final product actually uses. For example, if a bolt can only be torqued to the specified torque one time before it needs to be replaced, plan to make that bolt part of a sub-assembly that will not require removal of the bolt; or include the extra bolts required to disassemble and reassemble the product in the assembly/disassembly procedures.

3.2.4 Knowledge of Kaizan and Lean Production Techniques

Deciding which process improvement techniques to use can be challenging. When planning to improve a process:

- Identify the process to be addressed
- Select an approach
- Bring together resources
- Enlist a team

.1 Kaizan

Kaizan is a Japanese term that refers to continuous quality improvement through gradually changing small things for the better and setting and achieving standards that are increasingly higher than before. Kaizan techniques can be used to eliminate waste by addressing costs, defects, cycle times, and other waste. Poke-a-yoke techniques help identify flaws or errors in a process and mistake proof the process once the errors have been identified.

When implementing Kaizan, consider these ten suggestions:

1. Discard conventional ideas.
2. Think of how to do it, not why it cannot be done.
3. Do not make excuses. Question current practices.
4. Do not seek perfection. Do it right away, even if only for 50% of the target.
5. If a mistake is made, correct it immediately.
6. Do not spend money for Kaizen, use your wisdom.
7. Wisdom emerges in the face of adversity.
8. To seek the root cause of all problems, ask “Why?” seven times.

9. Seek the wisdom of ten people rather than the knowledge of one.
10. Kaizen ideas are infinite.[56]

.2 Lean Manufacturing

Lean production techniques focus on elimination of all waste in the production process. Reduction of cycle times, zero wait times, zero inventory, reduction of actual process times, scheduling efficiencies, and line balancing are achieved through the utilization of techniques such as value-stream mapping and identification and elimination of process steps that do not add value (see Figure 3-3 below).

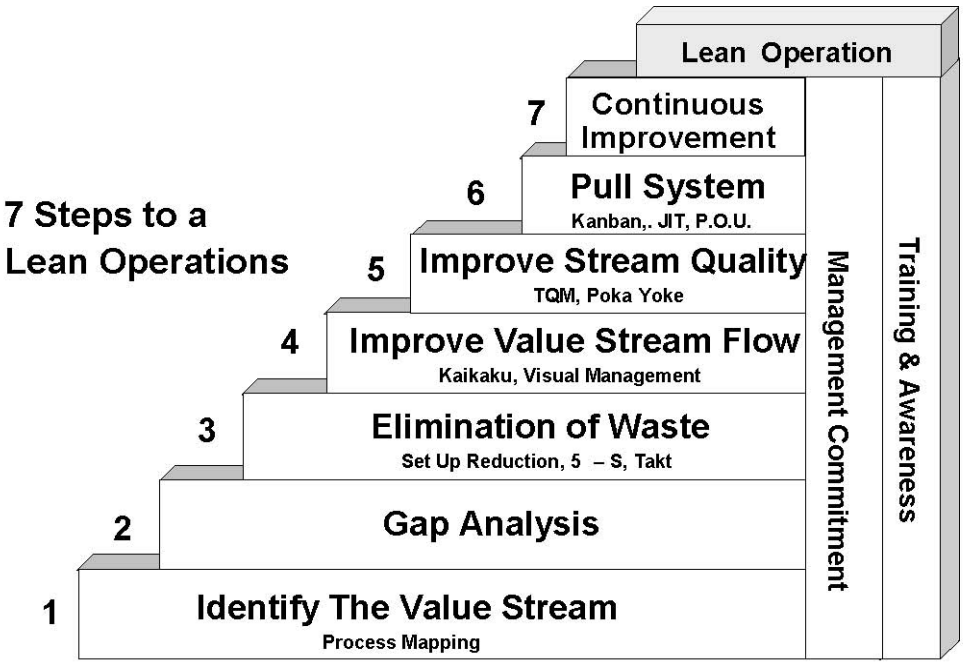

Figure 3- 3 Seven Steps to Lean Operations[57]

In order to achieve the lean manufacturing goal of zero waste, examine all aspects of a project for opportunities for improvement. Waste in organizations can be classified as being of the following types:

- Overproduction
- Transportation waste
- Inventory waste
- Motion waste
- Waiting, time
- Non-value-added processes
- Cost of quality: inspection, rework, & scrap

[56] Swati Chopra, "Changing with Kaizen." Available at http://www.lifepositive.com/Mind/work/corporate-management/kaizen-management.asp. Viewed 08/10/09.
[57] Figure used with permission of David Kazel, Close the Gap Manufacturing Group, Inc.

The result of using lean manufacturing techniques to eliminate waste is an increase in:

- Efficiency
- Throughput
- Profitability
- Customer satisfaction

3.2.5 Knowledge of Quality Analysis Techniques (TQM and Six Sigma)

The quality analysis "toolbox" includes a wide variety of items for engineering managers to use. At this time, the most widely used quality analysis techniques are total quality management (TQM), Six Sigma, and a combination of Six Sigma and lean manufacturing known as Lean Sigma.

.1 Total Quality Management (TQM)[58]

Total quality management focuses on improving all processes of an organization rather than relying on product inspection only. It emphasizes not only inspection statistics, but also organization-wide quality improvement in areas not normally inspected, such as customer service. All members of an organization participate in the improvements efforts. If management does not wholly embrace the TQM, a challenge arises. Employees realize they are being asked to "do as I say and not as I do," which can lead to morale problems.

TQM Process analysis tools include:

- Flow charts
- Failure modes and effects analysis (FMEA)
- Mistake-proofing

TQM efforts vary from organization to organization. Figure 3-4 (below) illustrates the focus of TQM efforts.

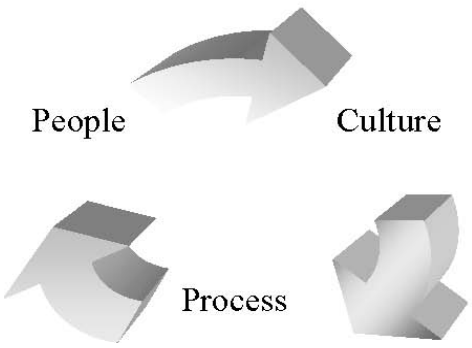

Figure 3- 4 The Focus of Total Quality Management (TQM)

[58] For more information on Total Quality Management, see *Quality Management: Introduction to Total Quality Management for Production, Processing, and Services (4th Edition)* by David L Goetsch. Publisher: Prentice Hall; 4 edition (2003)

TQM success is based on a combination of:

- Management commitment to continuous improvement
- Empowerment and teamwork
- Measurement of process quality
- Emphasizing excellence
- Expanding quality training

.2 Six Sigma

Opinions vary on the definition of Six Sigma. Some view Six Sigma as a philosophy, some view it as a set of tools including flow charts and control charts, while others view Six Sigma as a methodology using the approach known as DMAIC:

D — Define problem

M — Measure performance

A — Analyze process

I — Improve process

C — Control to hold the gains

The Six Sigma method is depicted in Figure 3-5 (below).

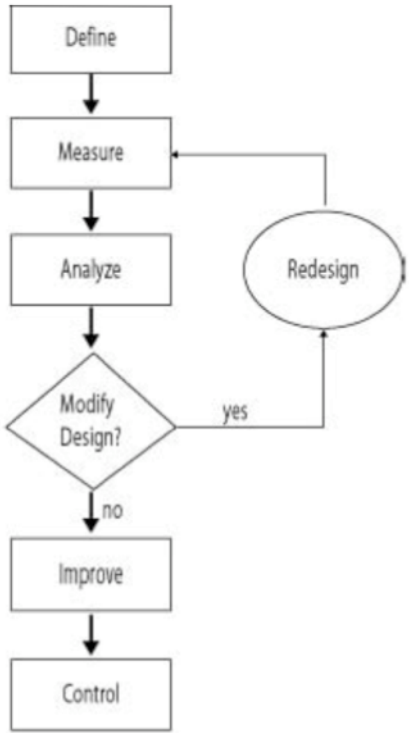

Figure 3- 5 Six Sigma Process Flow[59]

Six Sigma uses statistics to determine root causes of problems and address the changes required for improvement. Six Sigma teams are assigned projects that are well defined and have a direct impact on costs. Teams utilize management champions, referred to as Black Belts, who receive extensive training in statistics and project management, and Green Belts, who receive less training than the Black Belts and retain their original work assignments in the organization while working on the Six Sigma project. One of the drawbacks of Six Sigma, if improperly implemented, is that it can create an elite, autonomous group of Black Belts who have no connection to the shop floor processes.

With any process improvement activity, take care to ensure management support for the process chosen. Active management involvement greatly increases the likelihood of success.

3.2.6 Knowledge of Simulation Models and Applications

Simulation models can be used determine the effects of a product or process change without the expense of an actual full-scale trial. While prototyping can help debug the manufacturing process and product design, it can be time-consuming and costly. Computer simulation provides a useful and cost-effective alternative to such traditional testing methods. The rapid development of computer technology has made computer simulation affordable and doable for the vast majority of manufacturing and design projects.

[59] "Six Sigma The DMAIC Methodology." Available at http://www.asq.org/learn-about-quality/six-sigma/overview/dmaic.html. Viewed 08/10/09. Diagram reprinted with permission from American Society for Quality, Copyright 2006, http://www.asq.org.

Computerized simulation models can be used to determine the effect of a single change or multiple, simultaneous changes to a product or process. Many computer-driven design programs that include 3D design capabilities also include 3D modeling and simulation abilities. If a part is designed in three dimensions, surfaces of the solid model are defined using 3D modeling, and machining simulations are conducted using the software's simulation capabilities.

When a part is designed using computer aided design and manufacturing (CAD/CAM) technologies, software can be used to identify manufacturability issues such as inappropriate tool clearance, sequencing problems, or unacceptable wear and error rates. A virtual tool can be "test driven" over the part to check for clearance and other manufacturability issues. It is much more efficient to learn at the desk that a cutting tool will bind or break at the same point on each part than it is to bind or break the tools on the production floor. The desktop is also the best place to learn that a design simply cannot be produced as specified. Consider the equipment and tooling costs associated with a production trial that results in no ability to produce the product as originally designed. It is much better to change the design in the virtual stage than to attempt to reverse-engineer a process that is not capable of producing the desired result and may, in fact, never be capable of production.

Simulation models such as those employed by the U.S. Army Corps of Engineers in their Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire, can be used to evaluate several different alternative solutions to a given problem. At normal scale, each alternative would be prohibitively expensive to implement on a trial basis. In the simulation model, the relative merits and drawbacks of each alternative can be assessed.

For example, when dams on the Illinois Waterway were experiencing icing problems, operators were required to manually remove the ice from the gates by hand, either by chipping or using steam hoses. This was difficult, dangerous work, undertaken in adverse conditions. The potential for serious injury or fatality was unacceptably high. If, however, the ice was not removed, function of the gates was impaired, with the potential for inadequate control of water levels resulting in inadequate water levels for navigation. After testing several possible solutions during simulations in the Cold Regions Research and Engineering Laboratory, engineers were able to determine which alternative would provide the best solution to the icing/deicing problem.

Simulation models can also be used to determine the performance of equipment used to build parts. These simulation models can help to identify when a piece of equipment can be reused, when it needs modifications for most efficient operation, and when it will need to be replaced.

In addition to design and manufacturing simulations, the flow of product throughout an entire facility can be simulated. Materials availability, transportation issues, bottlenecks, and the location of each part as it progresses through the facility can be recreated in computer models. The broad bandwidth capabilities and large data storage capacity of today's computers allows for the use of increasingly sophisticated simulations that can conduct a wide variety of simulations simultaneously, rather than evaluating changes to one variable at a time, as was done in the past. Use of multi-disciplinary simulation software also increases the design and evaluation capabilities of a design team without requiring an increase in the number of staff.

Following the use of simulation methodologies, review the proposed project to determine product feasibility. Consider:

- Can the product be built?
- Does the production facility currently possess the equipment to produce the project, or will new equipment need to be purchased?
- Can it be built safely and efficiently?
- Does a sustainable market exist for the product?
- If a sustainable market does not currently exist, can a market niche be created that will generate enough sales to justify production of the product?
- Will the cost to the end-user be acceptable?
- Is funding available to implement the project?
- What will be the source(s) of project funding?
- Are suitable resources available for allocation to the project? Do suitable human resources exist? Will additional staff be required? Does the production facility have the capacity to schedule additional tasks of the type required to produce the product?
- Are there increased training needs associated with the project?
- Are there any regulations that must be considered in the manufacture, distribution, and sale of the end product?
- Will customers develop alternatives uses for the product, potentially creating liability issues for the manufacturer?
- Can the project be brought to market within a timeframe that will allow capture of significant market share?
- Will the project be profitable, or could resources be better used elsewhere?

3.2.7 Knowledge of Computer-Driven Software Systems That Can Translate Customer Information Into Product Design Requirements

Customer satisfaction is the driving force for many product improvements and for new product development. TQM, ISO 9000, Robust Design, and QS9000 all require consideration of the customer's needs, with documentation of what has been done to meet or exceed customers' expectations. On-going customer contact ensures that customer expectations do not drift during the design phase of the project.

.1 Customer-Focused Design Methodology

Hewlett-Packard (HP) customer-centered design services (CCDS) staff focuses on actively seeking customer input throughout the product development process. In addition to addressing usefulness and ease-of-use issues, the HP customer-centered design activities also look at ease of ordering and delivery, documentation, installation, ease of integration with third-party products, and effectiveness of customer support. Figure 3-6 below represents the HP customer-centered design cycle of activities.

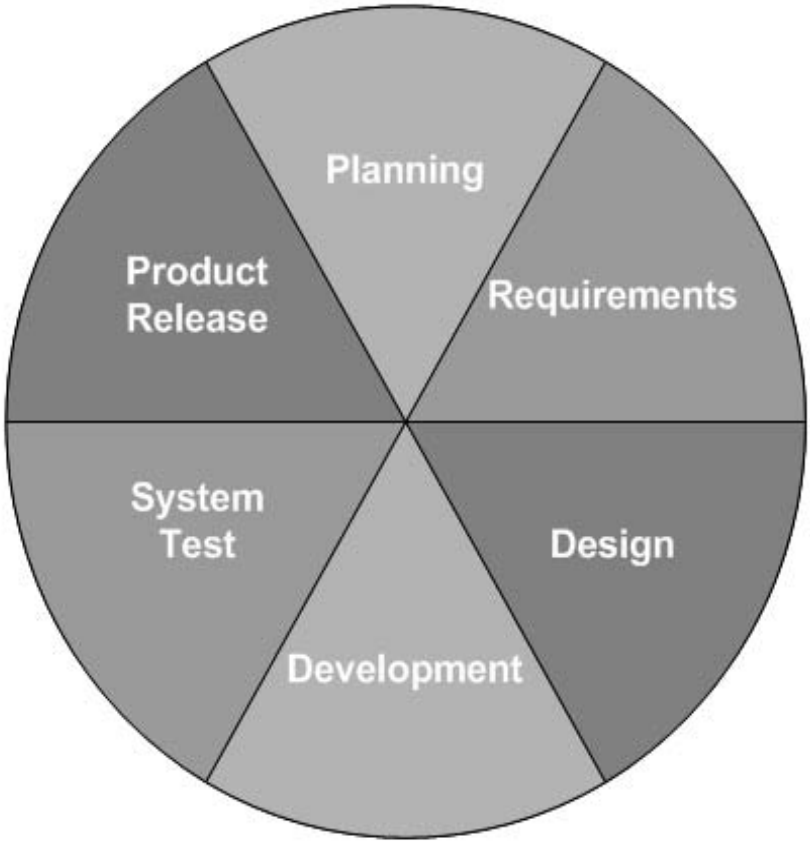

Figure 3- 6 HP Focus on Customer Requirements[60]

.2 Quality Function Deployment (QFD)

Quality function deployment (QFD) can be used to integrate the voice of the customer into the design and development process. QFD seeks the outspoken and unspoken wants and needs of the customer, prioritizes them, and translates them into specifications and product characteristics.[61] The multifunctional project team uses customer requirements, marketing information, and technical data to develop a prioritized list of engineering targets that the new design must meet.

When developing targets, consider:

- What are the customers' requirements (from customer questionnaires)?
- What is the relative importance of each requirement to the customer (again, from customer questionnaires)?
- What is the customer satisfaction level with existing products (from questionnaires)?
- What is the satisfaction level the project team hopes to achieve?

[60] Nancy L. Clark and Craig B. Neeley, "Customer-Centered Design at HP." Available at www.innovationforum.com/2003/clark.ppt. Viewed 08/10/09.
[61] Quality Function Deployment, The QFD Institute. Available at http://www.qfdi.org/. Viewed 08/10/09.

- What is the difference between this desired level of satisfaction and the current satisfaction level?
- What is the environmental impact of the product?
- What are competitors doing?

3.2.8 Knowledge of Techniques for Designing Experiments

Past performance of a process can be determined through the use of statistical process control. Future process potential can best be assessed through the use of designed experiments.

.1 Designing Experiments

A well-designed experiment varies several factors at once to account for the possibility of interactions among several variables, as opposed to an experiment that allows only one factor to vary at a time in a tightly controlled environment.

Use designed experiments to:

- Provide an estimate of the effect of various conditions or equipment
- Determine the sources of variation in a process
- Optimize a process

Guidelines for conducting designed experiments:

- Be there — it is important to actively participate in the experiment to ensure that the data is collected as planned. However, this does not mean that the engineering manager should operate the process and/or collect the data. In order to best simulate the actual process and to avoid bias in the data collection, actual production personnel should operate the process and collect the data.
- Randomize trials across the entire design.
- Runs should be independent and not influenced by prior conditions.
- Ensure that the product or process design is fully capable of withstanding some level of consumer or user abuse.

A practical application of how the design of experiments was used can be understood from this example. A heavy equipment manufacturer was experiencing an unusual failure in the tower section of its mid-sized end-loaders. (The tower is the portion of the machine where the operator enclosure rests and the part where the bucket/lift arm assemblies attach.) Although the design was believed to be quite robust, towers were developing cracks, which was an unexpected failure for this piece of equipment. Because of the seriousness of the failures and the possibility of injury to the equipment operator, further investigation was conducted.

The investigation revealed that these cracked towers were only occurring on vehicles owned by a specific customer. When that customer's equipment use techniques were assessed, investigators found that, rather than use explosives to remove rock from the face of the quarry for pick-up by the end loader, the owner's operating personnel were driving the end-loader

into the quarry walls with the bucket being used as a ram to remove the rock — not quite the use for which the equipment had been designed. Operators were instructed on the correct use of the equipment. When warranty claims were denied due to product abuse, the owner decided to pursue an alternative method of rock removal.

.2 Robust Design

Depending on project goals, there are numerous approaches to design and testing that engineering managers find useful, including robust design. To ensure, early in the process, that the design is able to fully address the project definition, robust design employs these concepts:

- Understanding the relationships between design parameters and the project definition
- Variation causes quality loss
- Two-step optimization
- Orthogonal arrays for matrix experiments
- Introducing "noise" into the experiment, including, but not limited to:

  --Parameter variations

  --Environmental changes

  --Operating conditions

  --Manufacturing variations
- Data analysis and prediction
- Identification and confirmation of interactions

In projects not employing robust design techniques, quality efforts are traditionally made in the testing and/or production ramp-up phases of a project, when it is often too late to make significant changes.

An example of robust design considerations used in the testing of a light bulb design is shown in Figure 3-7.

Making a Light Bulb	
Controllable input parameters:	Materials (filament, bulb, gas, glue, base, etc.) Construction steps (mount filament on base, put gas in bulb and glue to base) Tools (for bending filament, holding base and bulb, injecting gas, applying glue, etc.)
Uncontrollable noise factors:	Quality of materials (correct mixture of metals for filament, glass that can be heated without breaking, glue that will not deteriorate when heated) Following construction steps (number and tightness of wire wraps, amount of gas inserted, temperature of gas insertion, temperature and humidity when applying glue) Equipment variations (how tightly wire is held to mount filament, how consistently gas and bulb are held and fit together, pressure of gas applied)
Measurable performance response:	How long bulb lasts How bright bulb burns How much power bulb uses

Figure 3- 7 Robust Design: Making a Light Bulb

When evaluating robust design methods, it is necessary to instantiate multiple engineering systems models, simulate different robust design methods for each model, confirm by experiment, and analyze the data.47 Using robust design techniques helps ensure that the product/process performs correctly, even with the introduction of noise factors. It also provides the ability to quantify the economic consequences of variation.

Putting It Into Practice: What challenges have you experienced when testing a product using the design of experiments methodology? How have you overcome these challenges?

3.2.9 Applying the Tools and Techniques to Evaluate the Manufacturability of One Product or Alternative Products Considering Technical and Practicality Factors (Includes Assessment of Prototypes)

Often, new designs or processes will be evaluated by building a prototype. Prototypes are not always constructed in the manner that will be used during full production, but the construction of prototypes does allow designs to be tweaked along the way. The next prototype to be built will be based upon knowledge gained during the design and development of the prior prototype. It is not always known if a new design will actually work. Prototypes serve as the test for design functionality, illustrations of ideas, and can be used to gather early customer feedback.[62]

[62] "Prototyping." Available at http://en.wikipedia.org/wiki/Prototyping. Viewed 08/10/09.

The larger and more complex the design or product, the more advantageous it is to develop prototypes. Various designs can be assessed for manufacturability, cost, ability to meet the needs of the customer, and life expectancy.

Large equipment manufacturers build prototype models, send them to proving grounds and top customers for trial and feedback. Product designs are then improved through testing before full production begins.

When evaluating the manufacturability of a product, consider:

- Can the new design be constructed with existing tooling, or will new tooling (and increased costs) need to be a part of the design considerations?
- Are materials readily available?
- Do production personnel possess the knowledge, skills, and abilities to implement the new design; or will training need to be provided?
- Can the process required to complete production be controlled so that scrap and rework can be avoided?
- Are there any transportation issues involved — either within the production facility or outside? Is the product so large that it cannot be moved throughout the production facility? Will it need to be built in modules and then assembled on-site?
- If the product will be built in modules, how will functionality of the product as a whole be tested? Don't assume that if the parts are functional, the assembly will be functional.
- Does the new product need a special environment for construction, such as a clean room or a temperature-controlled environment?
- What alternatives are available for adaptation that will make the manufacturing process more efficient?

In order to evaluate the manufacturability of one product or a group of products, develop an assessment instrument to record all comments, problems, difficulties, and needed changes. It is also a good idea to record the decisions and activities that were effective, so that they aren't inadvertently changed during redesign. Evaluation of alternative products requires that all alternatives be scored against the same criteria, in order to determine which product is the best fit. The assessment instrument used can be as simple as a chart that is completed by hand or as complex as a custom computerized assessment.

Putting It Into Practice: In the highly regulated pharmaceutical market, products are developed, licensed, and marketed for what is often a very narrow market segment. Physicians and the end-user of the product often identify alternative uses for a drug, other than that for which it was originally licensed, by noting side effects that were not readily apparent when the product was originally released. Have you ever worked on a project, assumed that the project team had examined every possible use for the product, then learned that the consumer, through failure to follow product instructions or through experimentation, had developed an entirely different use for the product? What could be done differently to capture that information prior to product launch?

3.3 System Design Methodology and Life-Cycle Engineering Product/Process Creation

System design and life-cycle engineering provide a broad examination of the product/process to be created. Product or service specifications cannot be developed until the desired target has been well defined. Once the definition of the product/process has been completed, address the following questions in order to provide full assessment and determine the best solution.

- What design changes will be required, and what will the cost difference be, if a product is designed for a 20-year life cycle as opposed to a 10-year life cycle?
- Will the market support the extra costs associated with the 20-year life cycle? Conversely, what is the cost of product failure?
- Are the reduced costs of a shortened life cycle worth the reduction in useful product life?
- Is technology evolving so quickly that the product will be obsolete before it has a chance to wear out?
- What are the costs associated with routine maintenance?
- Does the production facility need to be shut down each year to complete maintenance tasks?
- What would the costs be if this was extended to every two years, or even every five?
- When a shutdown for routine maintenance occurs, what is the cost of lost production opportunity?
- Is this cost offset by the cost of the maintenance schedule that was chosen?

3.3.1 Knowledge of Integrated Product Design and Development Methods

In the past, product design was a time-consuming, sequential process that required one department to complete its portion of the design before the next department could begin theirs. With the advent of computer-based design applications, that process has been replaced with a simultaneous integrated design approach. Both are discussed below.

.1 Sequential Design

In the sequential design process of the past, product/project design often followed a sequence similar to the following:

- Planning
- Concept development
- System-level design
- Detail design — most often with individual details developed by separate departments
- Testing — the point at which it sometimes became evident that not all designer work was developed from the same set of criteria

- Design revisions
- Production ramp-up

.2 Simultaneous Integrated Design

With the increasing capacity and speed of computer workstations, engineers can complete design tasks simultaneously, shortening the design process considerably.

The technology now exists to use computers to turn a sketch into a design. Users no longer operate in silos, but instead, are members of multifunctional teams that draw on each other's strengths to develop the best design.

The sequential design process has been replaced with simultaneous, integrated design and development methods. In many instances, one individual can complete multi-disciplinary tasks that were, in the past, completed by several individuals from several different departments.

To determine the interrelationships in the design structure and identify integrated design opportunities:

- Interview engineers and managers
- Determine the lists of tasks and/or parameters each will address
- Ask each about inputs, outputs, interactions, and the strength of interactions
- Enter interview results in a matrix
- Verify matrix results with the interview participants

.3 Design Structure Matrices

Use design structure matrices to identify the interrelationships between various components of the design process. Figure 3-8 defines the three design configurations possible and the design structure matrix that results from each.

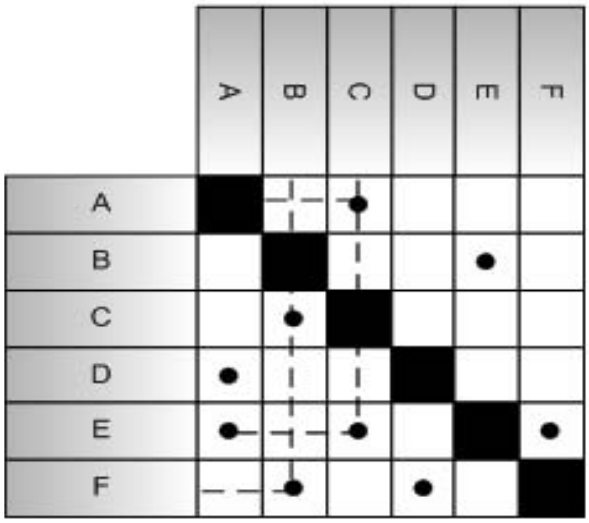

Figure 3- 8 Sample Design Structure Matrix

From the start of the process, the sketch can be developed into a solid model that the engineer can simultaneously subject to finite element analysis, first pass machining, numerical control path creation, and process simulations. Individuals can assume multi-functional roles within the design process, reducing the time required for design and testing.[63]

The benefits of integrated project design, especially for large projects, include:

- Performing multiple design activities in parallel
- Integrating subsystems to achieve an overall system-wide solution for the assigned project
- Mapping the interdependence of the processes to define the underlying structure for system engineering
- Designing an organization based upon the defined structure

3.3.2 Knowledge of Life-Cycle Engineering Analysis

Life-cycle engineering analysis approaches product design from the vantage of a product's life cycle, i.e., from its conception to the end of useful life. Performing this type of analysis:

- Highlights the most significant stages of a product's life cycle
- Assists with material selection
- Compares and contrasts alternative products

[63] Eric Doka, "Want to Maximize Productivity? Try Integrated Product Design," *Design News,* 55, no. 12, June 19, 2000, p. 90.

- Facilitates sensitivity analysis
- Identifies opportunities for product improvement in an efficient manner that provides data for timely, well-informed decision making

.1 Project Review

Many process redundancies and failed projects occur when a life-cycle engineering analysis is not performed during product development. To perform this analysis successfully, make sure to ask these questions:

- What is the unit of analysis?
- What materials are to be considered? What material substitutions are possible?
- What process substitutions can be made?
- What alternative products are available?
- What are the resultant energy requirements?
- What are the resultant materials requirements?
- What will be produced by the process — not only the product, but also emissions and by-products?
- What impact will the product, by-product, and resource consumption have, not only on the project, but also on the global environment?

.2 Environmental Impact

If environmental impact is more damaging than desired, consider the following options:

- What can be done to change the patterns of consumption?
- How can less material be used to achieve the same product functionality?
- Can less harmful materials be substituted?
- How can production by-products be reused or recycled?

In order to tabulate the results of life-cycle engineering analysis, it often helps to draw a flow chart that defines system boundaries and various data streams collected. Resources for data include published studies, scientific literature, industry records, government records, industry associations, and private consultants.

Putting It Into Practice: How important are environmental impact considerations during life-cycle analysis? How many resources do you personally use each day? What can you do to minimize your personal impact upon the global environment?

3.3.3 Knowledge of Factors That Influence Product Creation Such As Design for Environment, Design for Maintenance, Design for Reusability, Design for Service, Design for Disposal, and Design for Life Cycle Analysis (Design for X)

In order to develop the best design possible, it is often necessary to first define the criteria for which the product is being developed, i.e., is the product's environmental impact a key consideration? Is its maintenance or reusability a priority? Several such design criteria are discussed below.

.1 Design for Environment

Design for environment takes into consideration—and works hard to minimize--the risks that the product or process would pose to human health and the environment. It also develops practices that take environmental impact concerns into consideration.

.2 Design For Maintenance

Design for maintenance takes special care to ensure that product maintenance can be completed using safe, easy methods. Parts that require routine maintenance and replacement should be accessible to most individuals and not require Herculean effort to service. Engine oil dipsticks, for example, should not be hidden in spots that an octopus would have trouble reaching.

.3 Design for Reusability

Design for reusability acknowledges that just because a specific part of a product fails, it may not be necessary to discard the entire product. It may, in fact, be perfectly acceptable from both a cost and environmental impact perspective to divert usable parts of the product from the waste stream and reuse them to create other parts. For example, many automotive parts have been remanufactured for years. Consumer electronics are also often recycled for reuse.

.4 Design for Service

Design for service develops products or processes that are easy to maintenance and service. Disassembly procedures are provided so that service is easier to undertake and successfully complete.[64]

.5 Design for Disposal

Design for disposal views the design process from an often-overlooked angle. When the product's useful life is over, what are the disposal requirements? For some products, such as nuclear reactor fuel, the considerations are quite complex. For others, considerations are less intricate, such as the design for a packing carton that is left unwaxed and undyed in order to ensure the most efficient breakdown when the product enters the waste stream.

.6 Design for Life Cycle Analysis (Design for X)

Design for X creates a product or process that attempts to address a wide range of desired characteristics. It may be the most time-consuming design criteria to work with, since it is difficult to create a design that is close to perfection in all aspects.

[64] Jack Raplee, "DFMA to RP, ASAP." Available at http://www.memagazine.org/backissues/membersonly/september99/features/dfma/dfma.html. Viewed 08/10/09.

3.3.4 Knowledge of Cost Analysis Techniques

The goal of a cost analysis is to determine how you can deliver the desired product or process at the lowest possible cost. For example, through cost analysis you can determine which method of materials acquisition would be the most cost effective. Some questions to consider when completing a cost analysis include:

- What is the unit cost of the task or material?
- Which alternative provides the desired result at the lowest possible cost?
- Do the benefits of the project outweigh the costs?
- Is the project worth doing?

By defining and quantifying costs prior to a project's implementation, the cost analysis permits the team to uncover any unexpected costs before production has begun. This allows the design team an opportunity to modify the design so that such costs may be avoided.

It should be also noted that cost analysis alone cannot predict whether the least expensive alternative is actually the best alternative. The total project must be considered — not just cost.

3.3.5 Knowledge of Simulation Models

Simulation models allow you to simulate production of a part. By doing this, you are able to track production processes and identify productions problems, such as a bottleneck, before they occur. Production simulations also have the benefit of allowing you to assess the effects of changing several production variables simultaneously instead of being restricted to only seeing the effects of changing one variable at a time. In addition, they provide excellent training opportunities for personnel. Flight simulators, for example, have been used for years to help train pilots in a cost-effective manner.

.1 Simulation Practices

To be effective, simulation models must address the multi-disciplinary aspects of the project. The simulation process develops a functional mathematical model of the physical systems involved in the project and serves as the critical link between analysis and the realities of engineering.

The integration of modern engineering systems involves interactions between various engineering domains such as mechanics, electronics, fluid flow, thermal processes, and chemical processes. Care must be taken during simulation to ensure that:

- A modeling assumption that appears correct in one domain is not problematic in other domains
- The level of detail of the simulation is appropriate for currently available process control techniques
- The model addresses both design and implementation phases of the project
- The cost of the simulation model is in line with the project budget and scope

- Simplicity of the simulation model does not compromise effectiveness
- Methods are relevant to the variety of engineering applications involved in the project
- Model's complexity does not obscure the overall project objective and insight gained

.2 Block and Bond Diagrams

You can use both Block block and bond diagrams (Figure 3-9) can both be used to depict simulation models. Block diagrams:

- Establish the boundaries of a system
- Outline the elements contained within the scope of a task
- Identify inputs and outputs for components within a system
- Identify system/component inter-relationships
- Identify system redundancies
- Determine critical paths through the system

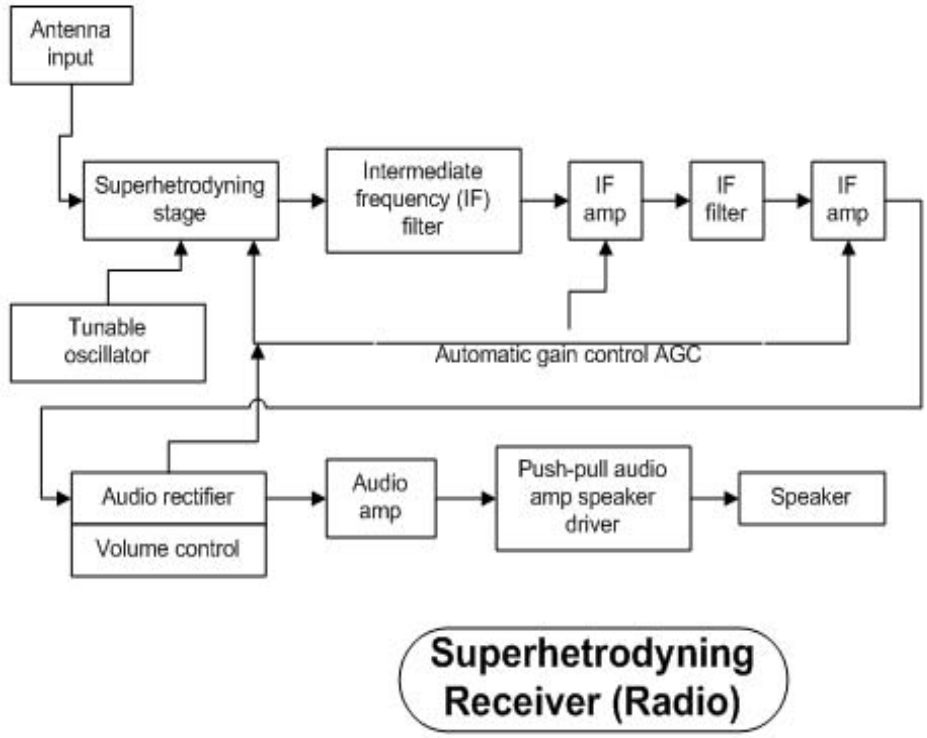

Figure 3- 9 Block Diagram from Superhetrodyning Receiver (Radio)[65]

Bond diagrams show the energy interaction between various components of a block diagram, denoting signal flow, not just the flow of information depicted in the block diagram. Bond diagrams can be compared to atomic diagrams that show the bonds between atomic particles.

[65] Oscilloscope Block Diagram & Schematics. Available at http://members.tripod.com/michaelgellis/scope.html. Viewed 08/10/09.

3.3.6 Knowledge of Web-Based Product Design Tools

Product design tools can be company and location specific, or broad-based. Many companies have global design teams. Web-based product design tools allow users in different locations to access the same information at the same time. Communication is enhanced and the project data is available wherever a team member is located (assuming that access to the Web is available.) The ability to have everyone on the same page at the same time eliminates errors created by users in a remote location (or a local who's a bit inattentive) using an outdated version of project data, designs, or specifications. Collaborative design tools allow each member of the team to work with the current revision of documents, to view the overall progress of the project, to serve as a resource for other team members, and to communicate real-time with the team as a whole.

High quality web-based product design tools include:

- Applications that are user-friendly. A long learning curve will severely impact the design process.
- Libraries of pre-determined modules.
- Modules that make sense to the designer (for example, a house designer wouldn't need a "half of roof plus side window" option.)
- Available modifications to default designs.
- The ability to translate between "user language" and "producer language" seamlessly. (The ability to identify when a manufacturing task cannot be completed as designed is key to this process.)
- The ability to determine the "right solution" to the task by helping to:
    - Design possible solutions
    - Develop prototype models
    - Test the model in a simulated use environment
    - Analyze the results of the simulation
    - Retest if necessary after modifications
- All of the tools and design variables necessary to complete the design.
- Ability to customize the design tools as lead users encounter the limits of the tools and ask for modifications or design the modifications themselves.

Increased use of collaborative, integrated, web-based design tools will help to shorten and improve the design to production process and allow designers to best meet their customers' needs and expectations.

Many of these services are offered now on a pay-as-you-use basis. This enables organizations to use the most up-to-date applications without making large capital expenditures and risking that the technology will too soon be obsolete.

3.3.7 Applying Techniques to Design Products, Services, and Processes From a Total System and Life-Cycle Engineering Perspective

The major life cycle cost of good design is incurred during the design phase, while the major costs of poor design are incurred during the production and service phases. It can be concluded that design determines 70 to 80 percent of the total life-cycle cost of a product (Williams, 2001, p.54).

From a systems and life-cycle engineering perspective, the overall view is that many sources are required to properly analyze data and convert it to design criteria. Tasks to complete include:

- Defining requirements
- Establishing design concepts that address the requirements
- Verifying the design will satisfy identified requirements
- Creating only systems, services, and processes necessary for the project
- Maintaining and operating the production system
- Dismantling the system at project end
- Disposing, recycling, or reusing system components[66]

In order to effectively design products, services, and processes from a total system and life-cycle engineering perspective, do the following:

- Develop a total systems engineering of life-cycle engineering plan. Judge the applicability of any proposed strategy, process, or methodology.
- Apply only the most essential tools to only those problems that are likely to be encountered.
- Recognize the value and limitations of modeling and simulation.
- Effectively plan for the gathering and analysis of data related to the project.
- Determine cost impact of manufacturing, maintenance, and disposal.

The long-term view afforded by total system engineering and life-cycle engineering provides the opportunity to plan effectively and implement best practices throughout the project duration.

Putting It Into Practice: What is the difference between "engineering" and "systems engineering"? Is there a major difference between the engineering process from the "engineering" view as opposed to the "systems" view?

[66] "Engineering Sciences for Modeling and Simulation-Based Life-Cycle Engineering." Available at http://divisions.asme.org/dscd/newsletter/newsspring99.pdf. Viewed 08/10/09.

Review

Upon completing the study of Domain 3: Products, Services & Process Development, you will be able to answer the following questions.

1. What benefits are realized by utilizing a team comprised of engineers from a variety of engineering disciplines?
2. Compare and contrast Kaizan and Lean production techniques.
3. What are the differences between TQM and Six Sigma quality analysis techniques?
4. Describe the benefits of using simulation models.
5. What are the benefits to analyzing product and process life cycles?
6. Why is the voice of the customer an important design consideration?
7. Explain why it is important to include assessment of end uses other than those for which the product is designed?
8. How has the increased importance of environmental concerns impacted the design process?
9. Describe how computer technology has revolutionized the design process.
10. What are the advantages of using interdisciplinary project teams? What challenges does this approach present?

For Further Information

- *The Quality Improvement Glossary* (2004) by Donald Siebels is great place to find the definition of terms and acronyms related to quality improvement.
- *The Quality Engineer Primer* by Bill Wortman is a good source for practical quality improvement application tools and templates.
- *Tom Peters Essentials — Design* by Tom Peters is a concise reference for the resolution of common design issues.
- *ISO/IEC 15288:2002, Systems Engineering — System Life Cycle Processes,* International Organization for Standardization. The ISO standard for system life cycle processes. (The ISO standard for software system life cycle processes is currently under development.)
- http://www.sourcingmag.com/ — The website for *Sourcing Magazine, a useful sourcing resource*.
- *Outsourcing: A Guide to Selecting the Correct Business Unit, Negotiating the Contract, Maintaining Control of the Process* by Stephen Brabb contains an effective overview of the outsourcing process with chapters devoted to specific industries.
- *Harvard Business Review on Strategic Alliances* by Harvard Business School Publications is a useful collection of expert advice on various strategic alliance topics.
- *Improving Work Groups: A Practical Manual for Team Building* by Dave Francis and Don Yount provides strategies for improving team work and productivity.
- *Building Productive Teams: An Action Guide and Resource Book* by Glenn H. Varney is an excellent resource for identifying and addressing problems associated with team work and productivity.
- *Fundamentals of Project Management, 2nd Ed.,* by James P Lewis (Amacon, 1995) contains a useful discussion of risk and risk management.

Domain 4: Engineering Projects and Process Management

Domain Champion: Benjamin (Duke) Dow, Ph.D.

4.1 Project Management Techniques

- 4.1.1 Knowledge of project management fundamentals (e.g. work breakdown structure, task and schedule development) and strategies (e.g. Earned Value Analysis)
- 4.1.2 Knowledge of project management planning and control concepts
- 4.1.3 Knowledge of techniques to determine scope, schedule, and budget
- 4.1.4 Knowledge of techniques for assessing project risk
- 4.1.5 Knowledge of techniques for project planning
- 4.1.6 Knowledge of project management resources

4.2 Scheduling Techniques

- 4.2.1 Knowledge of work schedule breakdown techniques to schedule work taking into account human resource constraints, supply chain constraints, and demand constraints
- 4.2.2 Knowledge of techniques for work scheduling

4.3 Strategies for Maintaining Customer Service and Satisfaction

- 4.3.1 Knowledge of techniques for obtaining customer feedback
- 4.3.2 Knowledge techniques for adapting work to meet changing customer needs in a reliable manner

4.4 Total Quality Management (TQM); Continuous Process Improvement

- 4.4.1 Knowledge of industry and regulatory standards for quality (e.g., ISO, ANSI, etc)
- 4.4.2 Knowledge of quality process management techniques (other than TQM)

4.5 Project and Process Tools

- 4.5.1 Knowledge of root cause analysis techniques
- 4.5.2 Responding to identified problems

Domain 4: Engineering Projects and Process Management

Key Words and Concepts

Cash Flow Analysis	Study of the cycle of cash inflow and outflow in a business
Cost of Capital	Actual cost of the capital project plus the opportunity costs associated with the investment
Internal Rate of Return	The return that a company would realize if it invested in itself or expanded, rather than investing elsewhere
Net Present Value	Analysis used by engineers during capital budgeting to determine whether or not a project should be undertaken
Return on Investment	A calculation which identifies profits to be realized or costs to be saved from implementing a project
Weighted Average Cost of Capital	Described by the formula: (1 minus debt to capital ratio) * cost of equity + debt to capital ratio * cost of debt
Work Breakdown Structure	Process that identifies all tasks required to complete a project, the order in which they must occur, the materials required, and the costs associated with each task

4.1 Project Selection

For many engineers, the development of new product and process designs is well within their comfort zone. Capital budget and resource planning may, however, be much more difficult tasks to complete. Rarely is only one individual responsible for a project. If necessary, utilize the expertise of other members of the project team to help navigate the less familiar waters of budget and resource planning. In some instances, it would be wise to hire a consultant to help with this process.

4.1.1 Techniques to Establish Financial Resource Requirements

While it would be exciting to manage a project where money was no object, the realities of most projects include the realization that there are limited resources available. A budget needs to be developed that will provide adequate funding for the project without putting the company out of business.

A myriad of software programs exist to help with the budget process and development of financial projections. A representative of the accounting department should definitely be a part of any project team. Utilization of an outside auditor to track expenditures may also be necessary.

Note the following key concepts to be aware of when developing budgets and projections.

.1 Cost of Capital

Cost of capital includes not only the actual cost of the capital project but also the opportunity costs associated with the investment. Opportunity cost evaluates what the capital would have earned if invested in another way. The *weighted average cost of capital* (WACC) can be described by the following formula:

WACC =
(1 - debt to capital ratio) * cost of equity + debt to capital ratio * cost of debt[67]

.2 Working Capital Management

Working capital (WC) is the amount of resources readily available to an organization. It can be defined by the equation:

WC = current assets - current liabilities

[67] "Cost of Capital." Available at http://en.wikipedia.org/wiki/Cost_of_capital. Viewed 08/10/09.

Limited resources need to be allocated between competing project opportunities. Working capital management balances the relationship between the company's short-term assets and short-term liabilities to ensure an adequate cash flow to address both short-term debt and upcoming operational expenses.

.3 Profitability and Liquidity

In order for a company to stay in business, it must remain profitable. To determine a company's profitability, assess the relationship between its profits and capital. Because this assessment can be complicated, it is best to perform profitability measurements with the assistance of an accountant and/or auditor.

Liquidity, on the other hand, is the ability of a company to meet its current obligations in a timely manner. To determine liquidity, review a company's balance sheet and assess the relationship between its assets and liabilities. Liquidity issues are best explained by example; money coming in tomorrow is no good if the company needs it today, unless creditors can be convinced to wait.

.4 Cash Flow Analysis

Cash flow is the movement of funds in and out of a business. Studying the cycle of a company's cash inflow and outflow is called a *cash flow analysis*. If the outflow is greater than the inflow in any given month, additional cash will be necessary the next month to meet the company's financial obligations. Since cash flows are rarely level from month to month—i.e., a company's revenue-generating capacity varies over the course of a year—remaining solvent requires that management plan for cash flow in advance.

.5 Tax Effects

Taxes and tax rates play an important role in a company's financial decision making. Anticipation of an impending tax hike in a particular sector, for example, may increase spending in that sector before the hike takes effect. Tax cuts in a particular sector, on the other hand, can spur growth and development in that area once the cuts take effect. For projects that will create jobs or retain investment in a specific geographical area, governments may offer tax incentives. Many municipalities, for example, offer tax abatement for new company's locating within their boundaries.

.6 Capital

Capital rationing is a critical issue that managers face on a regular basis. As stated before, there will probably not be unlimited access to funds for any project. More likely, budget constraints will be fixed, and the project cannot borrow or lend money.[68] Capital rationing limits the amount a company may spend on new investments and may be the result of a poor *return on investments* in the recent past or excess on-hand production capacity.

[68] Soulaymane Kachani, and Jerome Langella, "A Robust Optimization Approach to Capital Rationing and Capital Budgeting," *Engineering Economist,* **50,** no. 3, Fall 2005, p. 195.

4.1.2 Techniques to Establish Capital Resource Requirements

.1 Capital Resource Decision Making

Capital expenditures are relatively large investments that companies expect to recoup over a longer period of time. Companies tend to look at capital expenditures as related to projects. Capital decision-making processes involve several individuals and functions and will reflect the company's attitudes toward risk, technological capabilities, competition, financing abilities, etc.

Figure 4-1 below shows the four stages of capital expenditure decision-making:

1. **Initiation:** Need is identified by an individual or group
2. **Evaluation:** If the idea is reasonable, proposal is developed and reviewed formally and informally
3. **Appropriation:** Selection phase where proposal merits are evaluated
4. **Realization:** Actual expenditures are compared to planned amounts

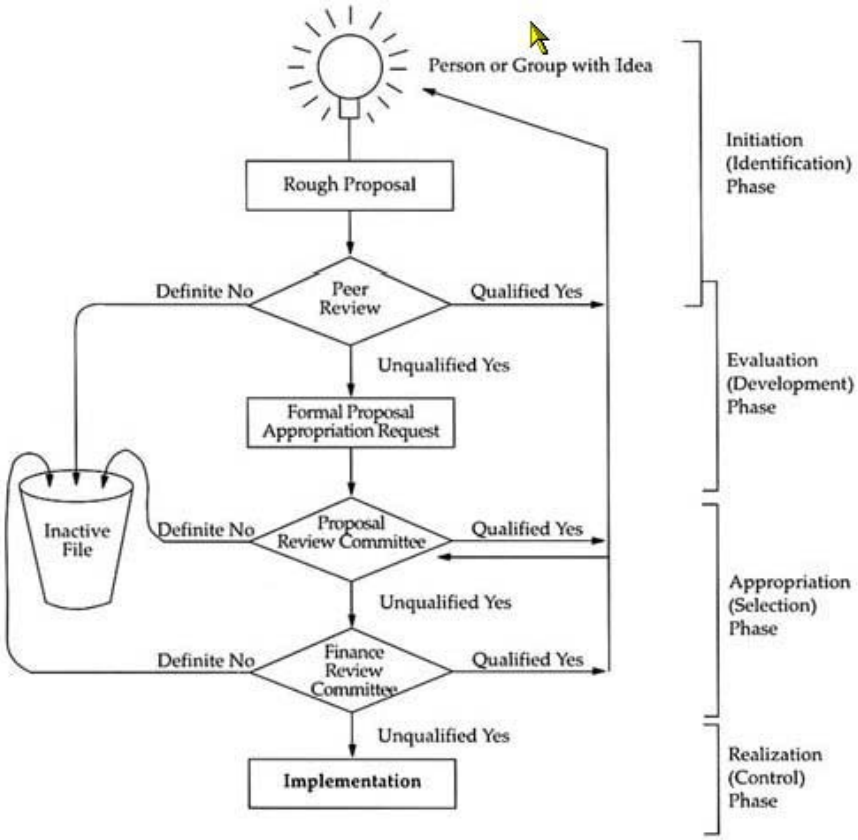

Figure 4- 1 Capital Expenditure Decision-Making Process[69]

[69] John Hampton, *AMA Management Handbook*, AMACOM Books, New York, NY, 1994, pp. 6-21 – 6-23. Diagram.reproduced with permission of AMACOM Books via Copyright Clearance Center.

.2 Net Present Value

Net present value (NPV) analysis is used by engineers during capital budgeting to decide whether or not to undertake a given project. It assists them in determining whether the costs associated with equipment purchase, facility costs, and equity can be returned within the time frame established for the project. To perform an NPV analysis, the present value of all cash inflows into the project is compared to the value of all eventual cash outflows, where the value of the outflows is adjusted to take inflation and investment returns into account (i.e., how does the value of a dollar in the future compare to the value of that same dollar today). If the NPV is positive, the project is considered doable. Software and online calculators can help you perform this analysis.

.3 Internal Rate of Return

Internal rate of return (IRR) is the return that a company would realize if it invested in itself or expanded rather than investing somewhere else. IRR analysis uses a single discount rate to evaluate every investment making it easier to use than an NPV analysis. However, when the market changes rapidly and erratically, and single discount rate do not apply, net present value (NPV) is the better analysis method. IRR is also not valid for longer-term projects where the discount rate varies over time.

.4 Discounted Cash Flow

Discounted cash flow (DCF) attempts to determine the present value of a company based upon its projections for future earnings. Recent accounting scandals have made discounted cash flow calculations to evaluate capital expenditures even more important. Developing a DCF analysis requires a sizable amount of work, but the results are less likely to be manipulated by aggressive accounting practices.

4.1.3 Techniques for Analyzing Return on Investment

Return on investment (ROI) is a measure that evaluates the efficiency of an investment or compares the efficiencies of several different investments. ROI calculations are made by dividing the return on an investment by the cost of the investment. Results are expressed as percentages or ratios.

$$\text{ROI} = \frac{\text{(Gain from investment - cost of investment)}}{\text{Cost of investment}}$$

Return on investment calculations are popular because they make it possible to compare several different capital projects in a relatively simple way. When using ROI, however, consider the fact that the calculations are easily manipulated by pickingn and choosing which items will be included as returns and costs. To avoid this when comparing multiple projects, ensure that the same inputs are being used in the ROI calculations for each project.

The degree to which ROI calculations are overstatements can be related to the following:

- Duration of the project (longer project length = greater overstatement)
- The capitalization policy of the company (the fewer items capitalized, the greater the overstatement)
- The depreciation rate used (rates greater than straight-line depreciation will result in higher ROI)
- Lag time between cash outlay and cash inflow (the greater the time delay, the greater the overstatement)
- The growth rate of the investment (investment in faster growth rate industry will result in a lower ROI)

  Some of the issues with ROI can be reduced by examining the expected performance of a proposed project over a wide variety of conditions.[70]

4.1.4 Establishing a Budget

.1 Preliminary Tasks

Prior to establishing a project budget, complete the following steps:

- Clearly define the project's scope, requirements, etc.
- Complete the breakdown of work required to implement the project. Using a *work breakdown structure* will help this process, as well as subsequent parts of the budgeting process.
- Develop a project schedule.
- Following the development of the work breakdown structure, assign costs to each task. Include costs for equipment, labor, and overhead. The proposed project schedule will help identify the need for increased labor costs.
- Determine available sources of funding.

.2 Initial Budget Process

When ready to draft an actual budget:

- Have budget department create a funding target. Gather your requirements accordingly.
- Review the requirements, justifications and numbers. Develop some sort of quantification system that can be used to rank options.
- Bring together a team of decision makers to help review and prioritize the proposed expenditures.[71]

When all information has been identified, total task costs to determine total project cost. Compare the timing of available funds to the funding needs defined by the work breakdown

[70] Karen Auguston Filed, "Plan for the Worst, Hope for the Best," *Design News,* **56**, no. 14, July 16, 2001, p. 7.
[71] David Cotts, *The Facility Management Handbook,* AMACOM Books, New York, NY, 1999, p. 79.

structure and project schedule. The result is a project budget that not only forecasts the amount of funding that will be required but also the time frame in which various amounts of funds will be accessed.

4.1.5 Determining Capital Resource Requirements

In order to determine capital resource requirements, you must first evaluate the need for capital equipment. Capital equipment and expenditures are items held for the long term and are not readily convertible to cash. Examples include:

- Land
- Buildings
- Equipment

Once capital asset requirements have been determined, you can develop capital resource requirements by assigning costs to those assets. Send requests for proposals (RFPs) to suppliers to help determine equipment costs. Real estate costs can be estimated from recent transactions in the project area. A large company with diverse holdings may have a knowledge base available in-house to assist with determining the capital costs of the proposed project.

As part of the requirement gathering process, prepare submission documents that include:

- Fiscal year
- Location
- Project title
- Program and category code (if applicable)
- Project number
- Project cost
- Cost estimate (by major project phases): phase, unit measure, quantity, unit cost, and total cost of phase
- Project description
- Project justification
- Decision device (net present value, etc.)
- Concept of drawing or rendering[72]

4.2 Project Management Techniques

The basic steps for managing a project are essentially the same regardless of whether the project is for an information system, the design of a product, construction, etc. These steps include:

[72] ibid., p. 80.

- Develop the project's general concept.
- Define the problem being addressed by the project, making sure the problem is not defined by symptoms.
- List possible strategies for conducting the project work; don't consider only one approach at this point.
- Assess the various strategies. Don't assume that any strategy will work or that nothing will go wrong.
- Develop a detailed action plan with enough detail to accurately portray the steps required to achieve success.
- Review the plan with ALL stakeholders. Don't ignore this step and proceed directly to implementation.
- Execute the project and monitor results. It may be necessary to re-plan at this point.
- Conduct a project postmortem when all work is complete to identify things that were done well and opportunities for improvement.

Close out the project and file final reports for use on subsequent projects.[73]

4.2.1 Project Management Fundamentals and Strategies

.1 Work Breakdown Structure

Use the work breakdown structure to provide a framework for all tasks in a project. Completion of the work breakdown structure involves determining the answers to the following questions:

- What tasks must be completed as a part of this project?
- Who will complete each task?
- How long will each task take to complete?
- What materials and supplies will be needed to accomplish tasks?
- What is the anticipated cost of each task?

Notice that having a work breakdown structure in-hand is the best way to answer the "Why does it cost so much?" question.

.2 Project Schedule Development and Costing

After each task is identified, its duration determined, and its expected cost estimated, you can begin to develop the project schedule. To do this, answer the following questions:

- Which task must be completed first?
- What is the next logical task?
- Can any of the tasks be completed in parallel?

[73] James P. Lewis, *Project Planning, Scheduling, and Control: A Hands-On Guide to Bringing Projects in on Time and on Budget,* McGraw-Hill, NY, 1995, pp. 23-29.

The project's critical path--the longest series of tasks required to complete the project--must be determined in order to determine the earliest start date for the project. Once the earliest start date is assigned, a run through of the proposed schedule will determine the earliest end time. Working backward through the proposed schedule will help to determine the latest possible start time. If the results are not acceptable, this is the time to revise the project — not after implementation.

.3 Project Management Strategies

Earned value analysis is a way to assess a project's progress, determine completion date, forecast final cost, and provide schedule and budget variance along the way. It allows you to compare planned work to the work actually completed so that you can ensure the project, its cost and schedule are progressing according to plan.[74]

Putting It Into Practice: What's more important: knowing where the project stands with respect to work accomplished, budget, or schedule? Or are knowledge of all three equally important?

4.2.2 Project Management Planning and Control Concepts

.1 Project Management Planning

Project management planning and control techniques are vital to project success. Inadequate planning results in project waste, including excessive materials, transportation, and labor costs. Some key points to consider when developing the project management plan include:

- Do not apply project controls if you have no plan.
- When developing the plan, make sure to involve the people who will actually be implementing it.
- Document the project fully — the project notebook will be a great reference the next time you need to develop a project plan.
- As early as possible (e.g., at a team meeting), get the approval signatures of project stakeholders.
- Make sure that stakeholders sign off on any significant changes to the plan.
- Keep track of the project scope. Allowing other things to become part of the project can destroy project plan (and budget).
- Define the problem to be solved before developing the implementation plan.
- Recognize that you don't have 20/20 foresight. Phase the planning if necessary.[75]

---

[74] "Earned Value Analysis." Available at www.cio.noaa.gov/itmanagement/evaslides.ppt. Viewed 08/10/09.

[75] James P. Lewis, *Project Planning, Scheduling, and Control: A Hands-On Guide to Bringing Projects in on Time and On Budget,* McGraw-Hill, NY, 1995, p. 50.

.2 Project Control

Project control is used to maintain satisfactory progress toward project goals. It requires that the project manager analyze variance in cost, scope, time, and performance on a regular basis, so that changes may be applied to the project in order to control its outcome. Failure to assess each criterion regularly can lead to a false sense of security. For example, if the project is within budget, but the schedule has not been adhered to, the manager won't find out until too late that an adjustment was needed. The resulting push at the end of the project can significantly escalate project costs.

Project control is best accomplished by empowering people involved in the project to move it forward, not via authoritarian management. In order to implement project control, you should employ these four basic techniques:

- Ensure that all projects are strategically aligned
- Create a culture that ensures a project management discipline
- Implement strategic project management best practices
- Create a strategic project measurement system [76]

In order to ensure that project management best practices are retained for future use, make sure that a project close-out meeting is held as soon as possible after project completion. The objective of the meeting is to review what happened during the project and what lessons were learned. Document lessons learned for use on future projects. Attendees should include the project sponsor, project manager, project team, and any stakeholders who would like to participate. Objectivity can be maintained through the use of a neutral facilitator.

4.2.3 Scope, Schedule, and Budget Techniques

Have you ever been involved in a project that never seemed to end, one that seemed to grow continuously, taking on a life of its own? The problem may have been that the project team never identified what the end result of the project would be or, even worse, failed initially to define what exactly what was to be done.

.1 Scope Development Techniques

Definition of the project scope (magnitude of the work being done) is a key factor in successful project completion. A project mission statement will help to define the project scope. Schedule and cost overruns often result from uncontrolled scope changes.

.2 Scheduling Techniques

Deciding upon an appropriate project schedule involves first assessing various strategies to determine which is best for project implementation, then developing an action plan. To schedule the project, make sure to complete the following steps:

[76] Michael Stanleigh, "From Crisis to Control: New Standards for Project Management," *Ivey Business Journal Online,* March-April 2006. University of Ontario, 2006. Available at http://www.iveybusinessjournal.com/view_article.asp?intArticle_ID=624. Viewed 08/10/09.

- Develop the work breakdown structure — what tasks need to be completed and when?
- Develop a network diagram — what is the sequence of tasks?
- Compute the critical path — will the project duration be acceptable? If not, revise the project plan now.
- Allocate resources — what will it take to complete the project, who will be providing those resources, and to what part of the project plan are they to be applied?
- Convert information to a Gantt chart
- Develop spending curves and baselines.

.3 Budget Development Techniques

When developing the project budget, include both direct and indirect costs. Examples of direct costs include wages, fringe benefits, consultant fees, travel, supplies, materials and services (e.g., long distance telephone, electricity, water, duplication and printing, postage, equipment rental, etc.). Indirect costs include those costs that cannot be directly billed to the project (e.g., overhead) as they are resources utilized on multiple projects (e.g., corporate officers, administrative assistants, etc.). "Contingency" and "miscellaneous" are not acceptable budget categories.

Once tasks have been identified in the work breakdown structure, resource requirements have been identified, and costs have been assigned to those resource requirements, you can determine the overall project budget by tallying all the identified costs. Take care to ensure that scope or timeline changes to the project are reflected in the revised project budget. Create change orders as the need arises. Don't wait until the end of the project to try to adjust the project budget. No one will be satisfied with the result.

Putting It Into Practice: Think of a project you worked on recently. What could have been done differently? Was a project closeout meeting conducted? What lessons were learned? Do you access information concerning lessons learned on past projects when you start a new project?

4.2.4 Assessing Project Risk

.1 Financial Risk Assessment

In order to conduct a risk analysis, perform the following tasks:

- Categorize similar/related risks to help identify related risks and identify potential dependencies.
- Determine the variables that affect the probability of identified risks and their potential impact.
- Determine the source of risk.
- Use risk analysis techniques to determine trade-offs, interdependencies, and timing of identified risks.

- Estimate risk factor or risk exposure by multiplying probability of the risk's occurrence by the financial consequence if the risk were to occur.
- Determine risk severity. This assists in prioritizing risks and focusing project control strategies.

To prioritize risks and calculate risk factors, you can use a risk assessment table like the one depicted in Figure 4-2 below.

Risk Assessment					
Risk Category	Brief Description of Risk	Cost if Risk Occurs	Probability of Risk Occurring	Risk Exposure	Priority

Figure 4- 2 Example of Risk Assessment Table[77]

Projects are generally managed as independent investments with independent budgets and independent schedules. This is effective for an organization with a number of small projects; however, as project sizes, scopes, and complexity increase, the risks of the projects should be assessed together to determine how the expected costs and benefits are affected.

As the total number of projects increases, the organization should assess the projects together as a portfolio. This will allow each project's risk and return to be compared to all other projects to determine the appropriate level of risk and return for the portfolio. Portfolio risk assessment will also identify projects that are competing for shared resources. Portfolio risk assessment is used to determine the potential for reducing existing risks in a cost-effective manner and to confirm the need for specific risk reduction measures.

.2 Environmental Risk and Legal Liabilities

Environmental risk analysis is a relatively recent development that is sometimes difficult to quantify accurately. When the Environmental Protection Agency (EPA) needed tools to assess environmental impacts and apply risk analysis to environmental problems, several environmental risk analysis tools were developed. A listing of environmental risk analysis tools is available from the Center for Risk Excellence.[78]

[77] "Risk Assessment." Available at http://www.ocio.usda.gov/cpic/doc/Appendix_F_RISK_ASSESSMENT_v1.pdf. Viewed 08/10/09.

[78] "Tools and Models," U.S. Department of Energy Center for Risk Management. Available at http://risk.lsd.ornl.gov/cre_tools.shtml. Viewed 08/10/09.

Assessment of legal liabilities will help to determine the need for controls such as performance bonds and payments bonds for contractors, additional insurance, damages for contract breech, waivers, and warranties. Many legal liabilities can be addressed within contract provisions. It's a good idea to have the legal team represented on the project management team.

4.2.5 Project Planning Concepts and Tools

.1 Successful Project Planning

In order to keep the project team focused and the project moving in a positive direction, a wide variety of project management concepts and tools must be used. Some are quite sophisticated, while others are decidedly low-tech. Substantial positive return can be gained from the use of some of the following simple, low-tech techniques:

- Detoxify negative environments — don't let unhappy people poison the team.
- Remember that the schedule belongs to the entire team and should not be dictated by the project manager.
- Use visuals — post the project deadlines, progress, and critical path in a location accessible to everyone. Formats for these postings may include Gantt charts depicting the project schedule, flow charts identifying the critical path, and graphs depicting progress toward the project goals.
- Get the project team away from their cubicles and involved in an activity as a group.
- Learn to say no to impossible deadlines and additions to the project scope.
- Confirm alignment of the project to business strategy.
- Don't sweep problems under the rug. Acknowledge and assess problems and utilize the strengths and experience of the project team to solve them.
- Allow team members to focus on their tasks, shielding them from meaningless distractions.
- Plan a few victory celebrations to highlight what's going right with the project.[79]

Numerous project planning software programs exist and can be useful in the development of the project schedule. Two common examples are Microsoft Project and Primavera.

Putting It Into Practice: Have you ever been involved in a project team whose environment was "toxic"? Did you enjoy attending those team meetings? What could have been done to improve the team's performance? Remember, there are no quick fixes for under-performing teams. Consistency will help to make the change to a more positive environment.

[79] Mary Brandel, "Tricks of the Trade: Some of the Best IT Management Techniques are Decidedly Low-Tech," *Computerworld,* **39,** no. 13, March 28, 2005, p. 47.

.2 Potential Project Failure

- Ignoring the project environment and stakeholders
- Pushing new technology to market too quickly. The most familiar engineering example of this is the Tacoma Narrows Bridge, which employed a well-understood technology (suspension bridge) in a new environment (a very long, narrow bridge built in a natural wind tunnel environment).
- Avoiding contingency planning — considering alternatives and developing alternative measures. All projects run into problems. How problems are handled determines the ultimate success of the overall project.
- Indulging knee-jerk reactions to problems. Public sacrifice of team members does nothing to solve the problem and causes fear of retribution.
- Letting inertia kill new ideas.
- Failing to conduct feasibility studies.
- Never admitting a project is a failure. Some projects will never be successful, no matter how many resources are consumed. Learn to identify failure, and terminate the project.
- Micromanaging the project and project team.
- Avoiding post-failure reviews. Reviews allow the project team to learn from the failure and, hopefully, avoid its repetition.
- Not developing an understanding of project trade-offs.
- Allowing politics and infighting to determine the crucial project decisions.
- Allowing someone with inadequate leadership skills to run the project.[80]

4.2.6 Project Management Expert Resources

Several organizations provide expert resources for project managers.

- ASME (American Society of Mechanical Engineers) provides e-Mentoring opportunities for ASME members.[81]
- PMI (Project Management Institute) provides publications, training, career development opportunities, and information resources for project managers.[82]
- For infrastructure construction, the Federal Highway Administration provides the services of their Construction and Project Management Team to assist with a variety of topics for the construction industry.[83]

---

[80] Jeffrey P. Pinto and Om P. Kharbanda, "How to Fail in Project Management (Without Really Trying)," *Business Horizons,* **39**, no. 4, July-August 1996, p. 45.

[81] eMentoring. Available at https://secure.asme.org/signin/ementoring.cfm. Viewed 08/10/09.

[82] Project Management Institute (PMI). Available at http://www.pmi.org/Pages/default.aspx. Viewed 08/10/09.

[83] FHWA Resource Center Construction and Project Management Team. Available at www.fhwa.dot.gov/resourcecenter/teams/construction/index.cfm. Viewed 08/10/09.

- ASCE (American Society of Civil Engineers) provides leadership and management journals for engineers.[84]
- IEEE (Institute of Electrical and Electronic Engineers) provides project management information in its digital library.[85]

4.3 Scheduling Techniques

4.3.1 Work Schedule Breakdown Techniques

Work schedule breakdowns show a project's ultimate goal, identifying the tasks and resources required to achieve it. In project management, the work schedule breakdown is second in importance only to defining the project.

.1 Work Breakdown Table

The first task when completing a work breakdown schedule is to create a work breakdown table that will provide you with the information you will need later in the scheduling process. In the work breakdown table, identify the following items: the name of the task, the duration of the task, and the events that need to be completed before the task can begin. Identify and list only the task that immediately precedes the task you are currently considering. There is no need to list all preceding activities. A sample table for recording items in a work breakdown schedule is in Figure 4-3 below.

Name of Task	Duration of Task	Preceding Event

Figure 4- 3 Work Breakdown Scheduled Task Record

.2 Effective Work Schedule Breakdowns

To crate an effective work breakdown schedule, make sure to ask the following questions:

- Is the status/completion of each task measurable?
- Are the start and end of events clearly defined?
- Does each activity have a deliverable?
- Is the duration of each activity reasonable?
- Are the work assignments independent?
- Is the cost easy to estimate?
- Are activity times easy to estimate?

[84] Leadership and Management. Available at http://www.asce.org/professional/leadership/. Viewed 08/10/09.

[85] IEEE — The World's Leading Professional Association for the Advancement of Technology. Available at http://www.ieee.org/portal/site. Viewed 08/10/09.

Because projects are dynamic, it can be difficult to maintain project equilibrium. Figure 4-4 identifies the balance required for project management.

Figure 4- 4 Balance required for Successful Project Management[86]

4.3.2 Work Scheduling

Due to market demands for product quality, flexibility, and order flow times, project scheduling has taken on a new importance.[87]

The initial schedule will often be constructed assuming unlimited resources. Following the initial schedule development, a more refined schedule can be created as constraints are identified. Project management software may make the scheduling activities easier to complete. Once constraints have been identified, the rest of the schedule can be built around them.

In order to accurately schedule resources, address the following:

- Make note of any holidays during the proposed duration of the project. Block them out at this point, and extended the schedule the number of days that have been blocked.
- Determine human resource availability. Is everyone available for a full day, every day, or are some individuals only available a limited number of days or hours per day? Don't overload your resources at this point — assume an eight-hour day and consider overtime later, if necessary.
- Double-check the availability of materials. Make sure you know the lead times involved to acquire the necessary materials. If your project duration is six weeks, and a necessary item has a lead-time of 17 weeks, you cannot possibly complete your project in the scheduled six-week window. If the long lead-time item is in the critical path for your project, you may not even be able to start the project within the scheduled project time.

---

[86] "A Primer on Project Management." Available at http://www.bgsu.edu/departments/envh/projmanage/sld002.htm. Viewed 08/10/09.

[87] Paul P. M. Stoop and Vincent C. S. Wiers, "The Complexity of Scheduling in Practice," *International Journal of Operations and Production Management,* **16**, no. 10, October 1996, p. 37.

- Determine whether the project is constrained due to certain time considerations. In many maintenance projects, for example, entire facilities will stop production during the maintenance period. Production will need to resume on time. Extending the maintenance shutdown is generally not a viable alternative.
- Identify the critical path activities, those that will make or break your project schedule. Make sure that your schedule provides resources to keep these activities working at all times.
- Determine the amount of float in your schedule — activities/times outside your critical path that are available for adjustment and reassignment of resources.
- Note early start and early finish dates for each activity.
- Following review of the project schedule, identify activities that can be overlapped without problems.
- Review the project budget and schedule to determine whether it would be more efficient to overload a resource in order to complete the project more quickly. Don't make the mistake of overloading every resource. Something is bound to go wrong, and the ability to adjust resources will be severely inhibited if there are no resources available to adjust. A project schedule that relies on large amounts of overtime for completion will likely result in significantly higher project costs.

Regardless of how carefully the project is planned, project management will always require a degree of flexibility. Remember, activity estimates are estimates, and have a 50/50 chance of being either overestimated or underestimated. The best project management advice may be: do whatever it takes to stay on schedule.

4.4 Maintaining Customer Service and Satisfaction

The best product innovation ever, completed in the most efficient manner possible, has very little value if it is not acceptable to the customer. Assessing customer satisfaction, however, can be difficult if the product is only in the concept stage and has yet to be produced. Customer service and satisfaction is a major component of quality system development. For example, ISO 9000 requires solicitation and documentation of customer feedback.

Remember, positive feedback is nice to hear, but all feedback — positive, neutral, or negative — should be reviewed. It is often the feedback of unhappy customers that provides ideas for beneficial change.

4.4.1 Obtaining Customer Feedback

.1 Benefits of Customer Feedback

Before soliciting customer feedback, assess the value it will add to the organization. Satisfied, repeat customers are crucial to the success of any business, whether it be a small pizza franchise or a large heavy equipment manufacturer. When calculating the value of one customer, do so over the long term, ten years or so. A customer who spends an average of $100 per week is worth more than $50,000 in sales to the company over that ten-year period. For industries with high-ticket products, the value of repeat customers is even higher.

.2 Customer Satisfaction Measurement

Customer satisfaction should be measured — not just satisfaction with the quality of the product, but also with the service provided. Be fully aware that price and product quality are not the only issues for most customers. Customers would prefer to be treated well and addressed honestly. Under-promising and over-delivering are much better that over-promising and lack of delivery. The following measures help to gauge customer satisfaction:

- Conduct formal customer surveys every 60 to 90 days. Conducting monthly informal surveys may also be useful.
- Facilitate systematic annual surveys. Use a third party to conduct these surveys, and share results widely — even if they are not what it was hoped they would be.
- On a regular basis invite informal focus groups of a few customers to meet with representatives of every operation — manufacturing, distribution, accounting, engineering, etc. — not just marketing.
- Ask some standard quantifiable questions such as "On a scale of one to ten, how were we to do business with?" Ask questions that compare the company with its competitors and determine whether the customer intends to do repeat business.
- Because no single survey or measurement is best, listen to the customers from several angles. Remember to ask for realistic feedback — then don't kill the messenger.
- Involve everyone in the customer satisfaction process — all levels of plant personnel, suppliers, wholesalers, and members of the distribution system.
- Measure everyone's satisfaction, not just that of the end user. Make sure suppliers, dealers, franchisees, and product representatives have the opportunity to provide feedback.
- Use the measurements to develop a composite "score" for individuals, groups, facilities, and divisions.
- Consider providing rewards for individuals and teams who provide high levels of customer satisfaction. All ages appreciate it when they are "caught doing something good." It is much more productive to reward acceptable behavior than to punish unacceptable behavior. The U.S. Army Corps of Engineers, for example, provides "Sustained Superior Performance" awards to individuals who go above and beyond on a continual basis, while providing smaller "On-The-Spot" awards to individuals who have made a difference in a specific area.
- Post key customer satisfaction numbers where everyone can see them.
- Include customer service in every person's personnel evaluation.[88]

You can conduct customer evaluations in a variety ways, from simple and informal to formal and complex. The challenge is to view every operation through the customer's eyes and not to assume knowledge of what the customer wants. The simplest, most direct way to obtain customer feedback is to just ask.

[88] Peters, Tom, *Thriving on Chaos,* Alfred A. Knopf, Inc., New York, NY. 1987. pp. 100-102.

Putting It Into Practice: Have you purchased a new product recently? Did you receive a customer satisfaction survey? Do you think those survey methods provide *any* reliable information for the manufacturer? Why?

4.4.2 Adapting Work to Meet Changing Customer Needs

Conducting on-going customer satisfaction surveys is necessary to assess changing customer needs and develop responses to them. Actively listening to customer feedback can also improve the product and design process.

In order to allow customer feedback to drive design innovation, everyone must be involved in the customer feedback loop. For example, design engineers who take part in customer satisfaction surveys are often able to directly apply those customer needs and wants into the latest design. Waiting for customer feedback to be quantified, sanitized, and transferred from marketing to engineering may cause design changes to miss the window of opportunity for customer use.

"Management proficiency is breaking down under the weight of an interconnected, real-time marketplace — an environment marked by accelerated change, complex interactive effects, and highly unstable economic conditions. Indeed, the rules have changed to the point that management needs a new blueprint for the future."[89]

Among the business requirements necessary to address changing customer requirements are:

- Develop a formal scope management and scope change process (so you can provide details around the cost,time and resource requirements for a change and get sign off before starting.
- Strengthening decision-making abilities through development of systems that can detect patterns and the underlying opportunities in those patterns.
- Modifying process work flow in a rapid and flexible manner to address customer satisfaction.
- Connecting people both within and outside the organization to provide a rapid response to change.
- Developing flexible IT systems that minimize obsolescence.
- Breaking large products into smaller subassemblies that can be rapidly changed and reassembled as the need arises.

While it is difficult to address constantly changing customer requirements, today's industry must in order to survive.

[89] "Businesses Face Technology Obstacles to Answering Changing Customer Needs." *Customer Interface,* **16**, no. 2, March-April 2003, p. 9.

4.5 Total Quality Management (TQM)

Use Total Quality Management (TQM) practices to ensure that product and process quality are continually evolving. TQM addresses:

- Continuous improvement of processes and products
- Problem-solving by employees who are enabled and inspired
- Excellence in management practices
- Customer satisfaction

Continuous quality improvement was most notably championed by W. Edwards Deming. It requires that an organization perform efficiently in order to produce a high-quality product that meets or exceeds the expectations of its customers.

Deming listed 14 pointers for top management to follow to ensure continuous quality management. An edited version of Deming's "14 Points" is listed in Figure 4-5 below. The 14 points apply to large and small organizations, to the service and manufacturing industries, as well as to divisions within the organization.

Deming's 14 Points for Management

1. Create constancy of purpose.
2. Adopt a philosophy of change.
3. Build quality into the product instead of trying to create quality by inspection.
4. Move toward single source suppliers.
5. Improve quality and production constantly.
6. Utilize on-the-job training.
7. Develop leadership.
8. Remove fear.
9. Eliminate barriers between departments. Allow people from throughout the organization to work as a team.
10. Eliminate slogans, quotas, and productivity targets.
11. Allow the worker of feel pride of workmanship.
12. Allow people in management and in engineering to feel pride of workmanship.
13. Adopt a self-improvement and education program.
14. Make everyone in the company a stakeholder in the change.

Figure 4- 5 Deming's 14 Points for Management[90]

[90] "Condensation of the 14 Points for Management." Available at http://www.deming.org/theman/teachings02.html. Viewed 08/10/09. "Condensation of the 14 Points for Management." Available at http://deming.org/index.cfm?content=66. Viewed 08/10/09.

4.5.1 Industry and Regulatory Standards for Quality

A variety of standards address quality. Some are voluntary, while others are mandatory. These standards may be different, based upon the location in which the product will be used. For example, California vehicle emission standards are more stringent than those in other areas of the United States.

.1 Quality Standards

Some of the organizations that establish quality standards for industry in the United States include:

ANSI: The American National Standards Institute — an organization that "administers and coordinates the U.S. voluntary standardization and conformity assessment system."[91] ANSI is a founding member of the International Organization for Standardization (ISO) and the U.S. representative to the International Electrotechnical Commission.

ISO: The International Organization for Standardization is an international organization that has developed standards for international business use. ISO 9000 addresses quality management while ISO 14000 addresses environmental management.

NIST: The National Institute of Standards and Technology is an arm of the U.S. Department of Commerce that manages the Malcolm Baldrige Award process.

.2 The Malcolm Baldrige Award

Companies that have well-developed quality management systems are eligible to apply for the Malcolm Baldrige National Quality Award. The Malcolm Baldrige National Quality Award was developed in 1987 to promote TQM. This award is given annually by the President of the United States to organizations who exemplify the best quality practices in the following areas:

- Leadership
- Strategic planning
- Customer and market focus
- Measurement, analysis, and knowledge management
- Human resource focus
- Process management
- Business results

Putting It Into Practice: Do you think that standards should be applied equally, regardless of location? At what point does the cost to the environment become more important than the cost of product modifications to comply with more stringent standards?

[91] "About ANSI Overview." Available at http://www.ansi.org/about_ansi/overview/overview.aspx?menuid=1. Viewed 08/10/09.

4.5.2 Quality Process Management Techniques (Other Than TQM)

Historically, quality functions within an organization were limited to a narrow, inspection-oriented role. These organizations attempted to inspect the quality of their products and then remove defects after they were created. As awareness has increased, product and process quality have been embraced by manufacturing organizations. As an organization progresses in its quest for quality, the focus shifts from quality control and inspection to continuous quality improvement of products, services, and processes. The challenge lies in establishing clear, attainable standards that can be consistently enforced.

.1 Process Management Tools

Several quality management tools have been developed to assist with data collection and analysis, identification, planning, and problem solving coordination. These management tools and a brief description of each are listed in Figure 4-6 on the next page.

Quality Management Tools	
Tool	**Description**
Affinity Diagram	A good technique for unfamiliar, new, or complex problems, this technique generates ideas, gathers facts, and helps to form patterns of thought by linking ideas.
Tree Diagram	Also referred to as a systemic diagram, the tree diagram outlines all of the steps necessary to achieve a given objective.
Process Decision Program Chart (PDPC)	Similar to contingency planning, PDPC is used to record the events that will take place from start to finish of a process or project. Contingency plans are included, in order to help keep the process on track. This is a good tool for problems containing very difficult, challenging steps.
bewMatrix Diagram	Matrix diagrams are a grid of rows and columns that depict the relationships between two sets of variables.. They are often used to show the relationship between objectives and methods, cause and effect, people and tasks, etc. One of the strengths of the matrix diagram is that some decisions can be made in a more objective manner.
Interrelationships Diagraph	The interrelationship diagraph is used for very complex issues. The method attempts to sort out intertwined relationships to develop a "best solution." Often defining the relationships that are causing the problem will frequently identify the solution.
Prioritization Matrices	Prioritization matrices arrange data into a matrix diagram with the degree of correlation entered into the proper cell. This tool is used to determine which option to use when key issues and concerns have been identified and alternative solutions have been identified. The math associated with this method can be cumbersome.
Activity Network Diagram	This tool helps to monitor, schedule, modify and review the activities, milestones, and critical times of a project. It helps determine schedules and the critical path of a project.

Figure 4- 6 Quality Management Tools[92]

.2 Additional Quality Process Management Techniques

- **Six Sigma**: Sigma is the Greek letter statisticians use to denote standard deviation. A level designation such as six (Six Sigma) is used to describe how well the process variation meets customer expectations. Six Sigma activities are based upon Six Sigma projects that will focus on one or more key areas: cost, quality, and schedule. Organizational support and infrastructure is evident in the creation of Black Belts and Green Belts. Six Sigma uses a standard methodology, DMAIC to implement the project. Properly structured Six Sigma projects start at the top and work down.

[92] Bill Wortman, *The Quality Engineer Primer,* Quality Council of Indiana, West Terre Haute, IN, 1997, pp. II-90 – II-104.

- **ISO Certification**: ISO Certification involves development and certification of an organization's quality system. Certification is provided by an outside auditor who evaluates the organization's operations and procedures and compares them to the ISO standards.
- **Kaizan:** Kaizan means "change for the better." Kaizan focuses on people by encouraging leadership to inspire workers to reduce costs, while producing higher quality goods in a shorter period of time. Kaizan approaches to quality process management include:
  - Customer orientation
  - Just-In-Time (JIT)
  - Total quality control Zero defects
  - Robotics
  - Small group activities
  - Quality circles
  - Productivity furtherance
  - Suggestion systems
  - Corporate labor/management relations
  - Quality betterment [93]
- **Failure Mode and Effect Analysis (FMEA):** Development of FMEA is credited to Ford Motor Company. FMEA is a proactive approach designed to predict process failures before they occur. It begins by describing the process, identifying potential failures and predicting the effects of the failures. The severity of each failure is assessed, and then root causes are identified. FMEA also defines the probability of each failure occurring and identifies control and detection practices — also assessing how difficult the failure will be to detect. Next, the preventative actions to be taken are identified, prioritized, and assigned to a responsible party who also documents what actions were taken. Finally, the results of the processes are evaluated and documented.
- **Quality Function Deployment (QFD):** Quality Function Deployment (QFD) is an approach to quality planning that aims to match customer requirements to products features or functions. The process begins by determining the specific customer needs and expectations. When successful, QFD minimizes development time and reduces the number of design changes needed.

4.6 Project and Process Tools

In order to determine an appropriate solution to a problem, analysts must not only consider *what* happened and *when*, but also *why*.

4.6.1 Root Cause Analysis Techniques

.1 Root Cause Analysis

Root causes are specific, basic reasons why an identified problem occurred. They are also causes for which management can recommend specific prevention solutions.[94]

[93] C. M. Chang, *Engineering Management: Challenges in the New Millennium*, Pearson Prentice Hall, Upper Saddle River, NJ, 2005, p. 121.
[94] James Rooney and Lee Vanden Heuvel, "Root Cause Analysis for Beginners." Available at http://www.asq.org/pub/qualityprogress/past/0704/qp0704rooney.pdf. Viewed 08/10/09.

Root cause analysis techniques are a learned behavior. In order to dig deeply enough into a problem to determine its root cause you must do the following:

- Truly define the defect, not the symptoms
- Use an interdisciplinary team-based approach
- Fully examine each level of cause and effect
- Identify necessary system changes
- Be impartial
- Ask why — several times — to determine the true root cause.[95]

.2 Root Cause Summary Table

A root cause summary table can be used to categorize data generated during data analysis, root cause investigation, and development of recommendations. An example of a root cause summary table appears in Figure 4-7 below.

Event Description		Event #
Causal effect #1	Paths through root cause map	Recommendations
Causal effect #2	Paths through root cause map	Recommendations

Figure 4- 7 Root Cause Summary Table

Once root causes have been identified and recommendations developed to prevent their recurrence, implementation of the recommendations must take place to reduce or eliminate the problem. One of the strongest points of root cause analysis is that it allows a problem to be addressed at its source and does not just address the symptoms.

4.6.2 Responding to Identified Problems

Once opportunities for improvement have been identified, and a remediation recommendation has been developed, a cross-functional team that represents all facets of the organization--design, engineering, manufacturing, and marketing--should respond to problems.. At no time should one segment of the organization complete its portion of the recommended fix before the other segments are aware of what has been recommended.

Knee-jerk reactions to identified problems should be avoided. Operating in crisis mode for most of the time creates a large amount of unnecessary stress and opens more avenues for error. Unless there is a true emergency that requires immediate action, such as a fire or a spill of toxic materials, take the time to adequately assess the situation and develop the best

[95] Steven Williams, "Dig Deep for True Root Cause," *CircuiTree,* 16, no. 11, Nov. 2003, p. 70.

solution to the problem. "Ready — aim — shoot" is the appropriate order of activities, not "ready — shoot — aim."

Determine the best course of action by examining the problem from several viewpoints — not just your own or that of your department. Solicit the input of those who are affected by the problem.

Document the investigation of the problem, the proposed solutions, and the rationale for the solution selected for implementation. Document, also, the implementation of the solution, and how well it addressed the identified problem.

Conduct a post-mortem review to determine what could have been done more efficiently and what needs to be done to remain problem free. For example, if, as part of the solution to your identified problem, some equipment parts were replaced and excessive wear was found on other parts, perhaps shortening the inspection maintenance interval would be a good idea.

Develop a reference library of problems and their solutions that can be referred to in the future.

Putting It Into Practice: Have you ever been involved in project that "repaired" something that was not the cause of the problem? What were the total costs incurred before the actual problem was resolved?

4.6.3 Project Management Software Programs

Computer software applications are evolving at increasing pace. The dramatic increase in processing speeds and capabilities now makes it possible for smaller organizations to have or use the computing capacity that once was only the domain of the industry giants. Initially, project managers created simple applications in spreadsheets. Today, servers, networks, websites, intranets, databases, and e-mail are all tools that engineers use to manage their projects on a daily basis.

Several service providers offer project management software products designed to meet the needs of everyone from individual project managers to very large organizations. Most programs are highly customizable and features differ widely.

Common project management software components include:

- Cost estimating
- Cost monitoring
- Multi-project scheduling and leveling
- Resource scheduling
- Simulation
- Task scheduling[96]

[96] Sunny and Kim Baker, *The Complete Idiot's Guide to Project Management*, Alpha Books, Indianapolis, IN,

.1 Evaluating Software Options

One way to determine whether a software package best meets the needs of a company or project is to measure the system from a functional perspective. This approach, referred to as a function point analysis, can be used to determine whether a tool, an environment, or a language is more productive compared with others within an organization or among organizations.

In this approach, the value of a software application is assessed using a value adjustment factor (VAF) that is based on 14 general system characteristics (see Figure 4-8). The impact of each characteristic is rated from zero to five — from no influence to strong influence.

Additionally, when the users are selecting a software package, it is wise to compare critical features of the applications being considered. Assign each feature a weight, and assess its value at time of review. Using a simple instrument like the one below (Figure 4-9) provides an expedient way to compare the value of each option.

2000, p, 187.

General System Characteristic		Brief Description
1.	Data communications	How many communication facilities are there to aid in the transfer or exchange of information with the application or system?
2.	Distributed data processing	How are distributed data and processing functions handled?
3.	Performance	What response time or throughput is required by the user?
4.	Heavily used configuration	How heavily used is the current hardware platform where the application will be executed?
5.	Transaction rate	How frequently are transactions executed daily, weekly, monthly, etc.?
6.	On-line data entry	What percentage of the information is entered on-line?
7	End-user efficiency	Was the application designed for end-user efficiency?
8.	On-line update	How many items are updated by on-line transactions?
9.	Complex processing	Does the application have extensive logical or mathematical processing capacity?
10.	Reusability	Was the application developed to meet one or many users' needs?
11.	Installation ease	How difficult is conversion and installation?
12.	Operational ease	How effective and/or automated are start-up, back-up, and recovery procedures?
13.	Multiple sites	Was the application specifically designed, developed, and supported to be installed at multiple sites for multiple organizations?
14.	Facilitate change	Was the application specifically designed, developed, and supported to facilitate change?

Figure 4- 8 Function Point Analysis[97]

[97] "Fundamentals of Function Point Analysis." Available at http://www.ifpug.com/fpafund.htm. Viewed 08/10/09.

Sample Software Evaluation					
		Package A		Package B	
	Weight	Value	Calculated (Weight x value)	Value	Calculated (Weight x value)
Chart and graphing features					
Creates modifiable standardized reports					
Establishes schedules					
Levels resources automatically					
Numerous resources can be assigned to tasks					
Options for network diagrams					
Stores several projects					

Figure 4- 9 Sample Project Management Software Evaluation[98]

.2 Making Selections

When selecting an application and vendor, remember also to:

- Be sure that it will integrate with existing software applications
- Determine whether the software is too complex for your needs, making it more difficult to learn.
- Strive for consensus among users. Include upper management approval.
- Consider the time and resources it will take for users to effectively work with the program. Check to see what kind of training, if any, the vendor provides.
- Carefully examine the agreement terms. Be sure there is adequate product and user support. How are requests for support handled? What is the fee structure? Do the hours of availability match company or project needs?
- Is the vendor reliable? Does it have a track record of success? Has it been in business for a sufficient period of time?

4.6.4 Simulation

Computer simulation models allow engineers to evaluate system or process behavior under various conditions or events (i.e., what-if scenarios). While still a relatively young field, recent years have seen tremendous growth in computer software simulation capability. As computers have become more powerful, portable and affordable, engineering simulations that once only extremely large companies could afford to do, are becoming commonplace.

[98] Sunny and Kim Baker, *The Complete Idiot's Guide to Project Management*, Alpha Books, Indianapolis, IN, 2000, p. 184.

.1 Benefits of Simulations

Computer simulations are very powerful tools. They are based on a relatively small set of assumptions and, as such, may be applied to a wide range of systems. Simulations are also extremely useful because:

- Engineers can experiment with design ideas — in different scenarios (what-ifs) and view results without actually needing to implement.
- Risks are reduced — related to developing a new process/product or modifying an existing one.
- Simulation processes makes it easier for individuals of different disciplines and locations to work together.
- Determining how different parts, components, and/or elements of systems interact is easier and more cost effective.
- Conditions are "controlled"– quantification of data and assurance of validity are increased.
- Resources are saved (time, financial, human, etc.), because analysis process is faster.
- Systemic problems are revealed by forethought invested in model design and documentation processes.
- Project implementation is more effective — parameters are clearly defined, tested, and best option is selected.

Remember, simulations will not:

- Make decisions or choose best options: they can only calculate data based on parameters/scenarios that are input.
- Accurately represent situations if the proper characteristics or data have not been appropriately designed/input into the model.

.2 When to Use Simulations

Simulation software can be purchased from under $500 (the basic packages) to over $50,000 (with 3D graphical animations). Naturally, companies will need to assess whether the higher priced software is valuable. For example, if a simulation predicts a serious production problem, this will enable the company producing the product to redesign the process before implementation. This preventative measure could save the company thousands of dollars, making the simulation software well worth the investment.

Simulations can be expensive, and trying to accurately describe complex real-world systems can be challenging; therefore, simulations should only be used when:

- The real system does not exist; and it is too costly, time consuming, hazardous, or simply impossible to build a prototype (e.g., space craft, nuclear reactor)

- The real system exists; but experimentation is expensive, hazardous or seriously disruptive (e.g., toxic materials processing, urban subway system)
- A forecasting model is required that would analyze long periods of time in compressed format (e.g., population growth, urban studies, forest fire spread)[99]

.3 Simulation Models

A variety of simulation models are described below.

Monte Carlo: Monte Carlo, as its name suggests, relies on chance by using random number generators. This model is useful when obtaining accurate sample data is too difficult (e.g., too costly, impractical) but can be reasonably estimated. It is also helpful when assessing errors. The biggest challenge is setting up an effective mathematical representation of the system.[100]

Statistical analysis: Statistical analysis involves drawing comparisons and making inferences from compared numbers. This can be both very useful and very misleading. Users must be careful that datasets carefully measure what is intended and comparisons are meaningful. Computer software has simplified the process by making the analysis faster and more consistent. Programs using the latest analysis methods have increased accuracy and validity. Most important in statistical analysis is how conclusions are drawn. One look at data could show that a company had increased its profitability by 25%. However, without the knowledge that an increase in demand had enabled product prices to double, credit could be given to increased productivity instead of increased prices.

FEM, FEA, and CFD: Finite element modeling (FEM), *finite element analysis* (FEA), computational fluid dynamics (CFD) and a host of other larger scale computer analysis programs are now available from an array of providers. These programs are often very helpful in that they can dramatically speed up the product verification phase of the design and development process.

Web-based simulations: Given that the computer simulation technology is evolving so rapidly and packages can be costly, many companies are now offering a variety of simulation operations on a "pay-as-you-go" basis. The advantage for users is that the company can often take advantage of the latest technologies without making capital investments.

Putting It Into Practice: Recall a time when you have used product management or simulation software. What was most valuable? What challenges did you encounter? What lessons learned can you bring to your next engagement with these types of programs?

[99] Roger McHaney, *Computer Simulation: A Practical Perspective,* Academic Press, Inc., San Diego, CA, 1991, pp. 1-6.
[100] "What is Monte Carlo?" Available at http://www.riskamp.com/library/. Viewed 08/10/09.

Review

After completing *Domain 4: Engineering Projects and Process Management,* you should be able to answer the following questions.

1. Describe how an engineering manager develops a capital budget. What elements are included, and who is involved in the process?
2. List the steps required to complete a work breakdown structure. Why is a work breakdown structure important?
3. What strategies are involved in project scheduling?
4. Describe how risk is assessed as part of the project management process.
5. What are some of the constraints that must be considered when developing a project schedule?
6. List some of the commonly used simulation techniques. What are some of the advantages of using computer simulation software?
7. Describe some of the ways to solicit customer feedback. Why is customer input so important to a project's success?
8. Discuss how quality standards improve processes and products.
9. Discuss the benefits of using finite element analysis (FEA).
10. What are the steps involved in conducting a root cause analysis? What are the benefits?

For Further Information

- *Juran on Planning for Quality* (1998) by J. M. Juran is a step-by-step guide to the Juran method of quality planning, quality management, and quality improvement
- *Thriving on Chaos a Handbook for Management Revolution* (1987) by Tom Peters is a reference for managers working in an environment of change
- http://www.nist.gov/public_affairs/factsheet/baldfaqs.htm. "Frequently Asked Questions About the Malcolm Baldrige National Quality Awards" provides information regarding the Malcolm Baldrige National Quality Award process, recipients, and applications.
- http://www.iso.org/iso/en/iso9000-14000/understand/inbrief.html — "ISO 9000 and ISO 14000 — In Brief" is a brief description of ISO 9000 and ISO 14000 standards.
- http://www.engr.usask.ca/~macphed/finite/fe_resources/fe_resources.html — "Internet Finite Element Resources" contains an extensive listing of finite element analysis software available on the internet.
- http://www.plant-maintenance.com/maintenance_articles_rcm.shtml — A listing of articles related to equipment maintenance strategies and RCM. "Plant Maintenance Resource Center, Equipment Maintenance Strategies, Preventative Maintenance and Reliability Centered Maintenance (RCM) Articles"

Domain 5: Financial Resource Management

Domain Champion: Robert Laney

5.1 Procurement and contract procedures; contract management

- 5.1.1 Knowledge of contract procedures and regulations
- 5.1.2 Knowledge of techniques for proper documentation of contracts
- 5.1.3 Knowledge of Uniform Contract Format (UCF)
- 5.1.4 Knowledge of various contract types
- 5.1.5 Overseeing the preparation of contracts
- 5.1.6 Reading and interpreting contracts
- 5.1.7 Managing contracts
- 5.1.8 Interacting with contract personnel

5.2 Funding sources

- 5.2.1 Identifying available and alternative funding sources
- 5.2.2 Knowledge of financial constraints
- 5.2.3 Developing funding proposals and implementing funding plans

5.3 Financial accounting and budgeting procedures; balance sheets; cash flow

- 5.3.1 Knowledge of budgeting techniques
- 5.3.2 Knowledge of alternative budgeting procedures
- 5.3.3 Knowledge of cash flow techniques and requirements
- 5.3.4 Knowledge of business plan fundamentals and key components
- 5.3.5 Evaluating the contents of business plans
- 5.3.6 Interpreting balance sheets,income statements (P&Ls)

5.4 Engineering economic analysis techniques

- 5.4.1 Knowledge of engineering economic analysis techniques such as NPV
- 5.4.2 Interpreting and applying the results of engineering economic analyses
- 5.4.3 Calculating economic equivalence, purchasing power of money, and estimation of costs
- 5.4.4 Audit processes, practices, key policies/regulations (SOX)

5.5 Capital Budget and Resource Planning

- 5.5.1 Knowledge and techniques to establish financial resource requirements including budget processes and financial projections
- 5.5.2 Knowledge of techniques to establish capital resource requirements (e.g., equipment facilities and equity)
- 5.5.3 Knowledge of techniques for measuring return on investment

5.6 Inventory control procedures and supply chain management

- 5.6.1 Knowledge of supply and usage procedures such as JIT
- 5.6.2 Knowledge of inventory control software, ecommerce
- 5.6.3 Monitoring inventory and ensuring sufficient supplies

Domain 5: Financial Resource Management

Key Words and Concepts

Balanced Scorecard	A measurement and management system that links financial data with strategic planning activities
Balance Sheet	The statement of a company's assets, liabilities, and owner equity at a given point in time
Enterprise Resource Planning (ERP)	Software applications designed to integrate company information and automate as many basic functions as possible
Income Statement/P&Ls	An activity-oriented financial statement that summarizes a company's revenues and expenses over a specific period of time
Just In Time (JIT)	A supply chain management approach designed to reduce inventories and increase speed of materials purchasing
Net Present Value (NPV)	A calculation of the present value of cash inflows and the present value of cash outflows used to determine whether an investment or project is profitable
Return on Investment (ROI)	A calculation of profits to be realized or costs to be saved as the result of a project's implementation
Uniform Contract Format (UCF)	A template of standard contract elements to use when creating engineering contracts

5.1 Procurement and Contract Procedures; Contract Management

5.1.1 Knowledge of Contract Procedures and Regulations

Contracts are legally binding documents. Contracting documentation needs to be reviewed carefully for potential problems (e.g., oversight issues, concerns about deliverables). Many organizations have a department specifically designated for determining contract procedures and the best methods for their implementation. Whenever available, use their knowledge and expertise.

.1 Generic Contracts

Organizations often create generic contract formats for use when creating contracts related to specific projects. Using the generic formats can substantially reduce the amount of time and effort required to draft the document. Remember, however, that when using these generic formats, the resulting contract must still be reviewed by the project team to ensure that it complies with the project scope and any legal requirements.

.2 Legal Requirements

Contracts are regulated by law, and in many instances regulatory agencies have developed mandates that must be included in contracts. Projects that use governmental funding sources and contracts with governmental entities are often subject to even more stringent regulation than private contracts. Contract regulations can include:

- Davis-Bacon Act — prevailing wage requirements and the wage surveys and certified payrolls that accompany them
- EPA mandates for adherence to environmental impact guidelines
- Disadvantaged Business Enterprise (DBE) quotas requiring a specific portion of the contract work to be performed by a DBE
- Inspection requirements
- Permitting requirements including but not limited to:
  - Utility connections such as water and sewer permits
  - Storm water detention requirements
  - Emissions permits
  - Transportation permits
- OSHA requirements for worker safety
- Industry specific contract provisions, such as necessity for a fire watch in a refinery or chemical production facility
- Interstate commerce regulations that limit the transportation of hazardous materials or waste
- Open competitive bidding regulations for governmental agencies
- Material certification requirements

The legal department representative to the project management team serves as the team resource for contract review as it applies to contract procedures and regulations. In the absence of a representative from the legal department, experienced procurement department representatives are most able to complete the contract review.

5.1.2 Knowledge of Techniques for Proper Documentation of Contracts

Documentation associated with contracts can be broken out into the following categories:

- Contract administration
- Daily work reports
- Payment information
- Change orders
- Civil rights/personnel issues
- Materials management

.1 Contract Administration

Contract administration documentation includes the project schedule, specifications, contract funding sources, a list of subcontractors and vendors, records of any contract disputes, and any other documents specific to the administration of a given contract.

.2 Daily Work Reports

Daily work reports document various dimensions of a day's work. This includes work site conditions, the names of on-site contract administration and contractor personnel, on-site equipment, a description of work completed, and the results of any field tests. The reports can be completed in a project notebook, a pocket calendar, project-specific daily report forms, or via laptop computer. Because these reports are an integral part of the contract administration process--and because they are used to prepare and validate payment requests--they should be completed in a timely manner. Ideally, the daily report should be completed by the end of the day. Waiting to document the day's activities on some future date—a date where spare time magically appears—is not advised.

.3 Payment Information

Contracts include the following elements specific to payments: a contractor's request for progress payments and tracking of payment request authorization. The contract must spell out elements such as incentives and disincentives, use of stockpiled material, contract adjustments and retainage. Documentation of payments would refer back to the contract.

It is often wise to develop a cover sheet for each payment request. The cover sheet should include a checklist of steps that must be completed for progress payments to be approved. The checklist will be useful to both the contractor and contract administrator. The contractor is able to verify that all requirements have been met prior to submitting a payment request, and the contractor administrator can verify that all information has been received in the necessary format. Requiring contractors to submit payment requests in a standard format also

ensures that the contract administrator will not need to make a judgment call regarding whether or not the payment request meets the contract requirements.

.4 Change Orders

The process for requesting a contract change must be defined in the contract documents. As with payment requests, the use of a standard format for change requests will help eliminate confusion and excessive paperwork. By making the process less confusing and cumbersome, standardization also decreases the likelihood that work will have to stop while a change request awaits approval.

.5 Civil Rights/Personnel Issues

Civil rights documentation includes information concerning the goals, guidelines, and mandates for disadvantage business utilization, tracks the progress toward on-the-job training goals for disadvantaged businesses used as subcontractors, and provides the data required to complete equal employment opportunity (EEO) reports.

.6 Materials Management

Materials management documentation includes records of materials usage, certification of materials, records of completed testing, and the results of that testing.

Be sure to define a contract's documentation requirements in the contract itself. Follow contact documentation requirements in order to protect the project, its stakeholders, and those who are parties to the contract.

5.1.3 Knowledge of Uniform Contract Format (UCF)

Uniform Contract Format (UCF) provides a template for use when developing contracts. It is not necessary to reinvent the wheel each time a contract must be developed for a project. Use of uniform contract format allows the project management team to define the scope of the project, identify deliverables, and determine project specifications. The team can then develop a contract for the project by inputting the project-specific variables.

.1 Front-End Documents

Uniform contract format documents include a set of contract "front-end" documents. These incorporate:

- Identification of the party for whom the work will be done
- Scope of work
- Bidding requirements including, but not limited to:
    - Requirements for bid bonds
    - Requirements for performance bonds
    - Insurance requirements
    - Permit requirements
- Instructions to bidders
- Bid forms

- Instructions for payment requests
- Definition of the time line, work schedule, and work hours of the project

.2 Specifications

Project and materials specifications follow front-end documents. Each specification section follows a set format. Specifications are separated into divisions of related activities. Use of uniform contract format allows an organization to develop a reference library of specifications that can be reassembled into new contracts with a minimum of effort and a reduction in the likelihood of error.

An excellent example of the use of uniform contract format is the contracts developed for construction or reconstruction of federal aid highways. Contract formats and requirements are well-defined; and since a large number of contracts for the same type of work are awarded each year, the use of uniform contract format makes it possible to pull the appropriate sections together from the specification library. Additionally, the first draft of the contract can be completed with relative ease.

Putting It Into Practice: What value do you place on a uniform contract format? How much do you think it would cost, and how long would it take, to develop a totally new contract format each time you issued a contract?

5.1.4 Knowledge of Various Contract Types

Engineers use a variety of contract types, each with a specific use. Some are useful in a wide variety of situations, while others have a more limited application. Common contract types include:

.1 Fixed Price Contracts

- Firm fixed price contracts — price is not subject to adjustment after contract award.
- Fixed price incentive contracts — a fixed price contract that provides for adjusting profit.
- Fixed price contracts with prospective redetermination — fixed price for initial term of contract with the potential to redetermine price for subsequent contract performance.
- Fixed-ceiling-price contracts with retroactive price redetermination — sometimes used for research and development contracts that have a short time frame and no fair and reasonable fixed price can be determined. The contract has a fixed ceiling price.
- Firm-fixed-price, level of effort contracts — contractor provides a specific level of effort (such as a research report) within a specified time frame.

.2 Cost — Reimbursement Contracts

- Cost contract — reimburses contractor costs but provides no fee.
- Cost-sharing contract — contractor receives no fee and is reimbursed only for the agreed-upon portion of costs.
- Cost-plus-incentive-fee contract — provides initial contract fee plus reimbursement of agreed-upon costs.

- Cost-plus-award-fee contract — provides an initial fee and an award based upon evaluation.
- Cost-plus-fixed-fee contract — provides a fixed fee in addition to agreed upon costs. May allow for readjustment of costs.

.3 Other Contracts

Incentive contract: Provides an incentive target for the contractor. Costs that hit the target receive the incentive payment. Costs that exceed the target result in a downward adjust of the incentive payment. Costs that are below target result in an upward adjust of the incentive payment.

Indefinite-delivery contract: Does not procure or specify a firm number of supplies or services, other than the contract minimum and maximum.

Time and materials contract: Provides for acquisition of labor hours at an agreed upon rate that includes wages, benefits, overhead, and profit, and for acquisition of materials at cost plus material handling costs.

Labor hour contract: Provides for acquisition of labor hours at an agreed-upon rate that includes wages, benefits, overhead, and profit. Does not include acquisition of materials.

Letter contract: Written preliminary contract that authorizes immediate manufacturing of supplies or performance of services.[101]

5.1.5 How to Oversee the Preparation of Contracts

Contract preparation should not be a one-person function. A team-based approach to contract preparation is best, because it:

- Uses the expertise of individuals with the most knowledge of a given portion of the contract as that portion of the contract is prepared.
- Reserves the services of other team members for those areas where they possess the most knowledge and expertise.

As project manager, provide team members with all relevant standardized specifications from the corporation's specification library. This enables the team to edit existing specifications rather than having to start from scratch. When team members have created their draft specification sections, ask the individual with the best grammar, spelling, and proofreading skills to assess the contract as a whole. Verb tense, word order, and the correct spelling of words that sound alike (homonyms) can have a great impact on the meaning and enforceability of a contract. Request assistance from this person privately rather than risk embarrassing individuals without these skills or having to turn down someone who may volunteer regardless. If collaboration software is available, using it will speed the review and revision process.

[101] Types of Contracts. Available at http://acquisition.gov/comp/far/current/html/FARTOCP16.html. Viewed 08/10/09.

Legal departments conduct final contract reviews prior to release.

In drafting the contract, make sure to do the following:

- Identify the contractor in a consistent manner throughout the contract.
- Confirm that contract dates are consistent throughout the contract. Contracts are not the place to inadvertently insert the wrong year.
- Make sure that all titling and numbering is correct. Don't mix up or leave out pages.
- Define specific contract terms.
- Make sure that all standard *terms and conditions apply to the contr*act. If they don't, recreate that portion of the standard terms and conditions. If this is not possible or cost-effective, then line out and initial the parts that don't apply.
- Include procurement and bidding information.
- Gather all required signatures. For corporations, two signatures may be required — one from a president or vice president and the second from a secretary or treasurer of the corporation.
- Include all necessary attachments.
- Be sure that all corrections have been initialed by both parties.[102]

5.1.6 How to Read and Interpret Contracts

The task of reading and interpreting several hundred pages of highly technical or formal contract language can be difficult. Unfortunately, the only way to adequately determine what is contained within a contract is to read it in its entirety. You should never sign a contract it until you've thoroughly read and understood it.

.1 Reading Contracts

Ask individuals with the necessary knowledge, skills, and experience to read the contract. . These individuals can help separate specific terms in the contract that must be executed from standard terms common to most contracts.

To make the contract review process manageable, break the document into related. When reviewing those sections, try to do so with as little interruption as possible; frequent interruption can make it difficult to absorb all of the contract's details.

.2 Interpreting Contracts

It is imperative that the contract manager understands how a contract will be interpreted in case there is a dispute that must be resolved through the court system. Courts use the contract language to determine what is or is not enforceable. The following rules, along with others, are used by the courts when determining enforceability.

[102] Checklist for Drafting Contracts. Available at http://www.passhe.edu/executive/counsel/Documents/list.pdf. Viewed 08/10/09.

- Interpret the terms in a contract in order to give them a meaningful, lawful, and effective meaning.
- Negotiated terms take precedence over standard terms and conditions.
- Specific terms carry greater weight than general terms.
- General terms are given their commonly accepted meaning, and technical terms are given their normal technical meaning unless there is something in the contract that otherwise defines them.
- Whenever reasonable, normal course of conduct is interpreted as being the intention of the contract parties — "standard practice" of the industry will be assumed to be applicable.
- Whenever a term or promise has more than one possible meaning, it will be interpreted against the party who drafted the term or promise.[103]

Because it is not wise or cost effective to decide a contract interpretation through the court system, enlist all company resources to read and interpret the contract before it is finally executed.

5.1.7 How to Manage Contracts

Contract management involves:

- Managing the relationships between the buyer and the contractor
- Managing changes to the contract
- Documenting contractor performance
- Managing outside buyer contract considerations

.1 Contract Managers

The contract manager has responsibility for all aspects of the project. Management of the contract requires that the contract manager have an in-depth understanding of the contract and the project, in addition to the ability to ensure that contract requirements are followed by the contractor. Although the contract contains the guidelines for the project and specifies the work that the contractor must complete, contract managers must remain flexible and willing to work with the contractor when changes are required. A good contract manager does not assume the role of enforcer, but rather the role of facilitator.

.2 Knowledge, Skills, and Abilities

To be able to successfully manage contracts, the contract manager must possess:

- The ability to read and understand complex contract language.
- The ability to apply the requirements of the contract to the real-world conditions of the project site.

[103] Michael J. Cole, "Interpretation of Contracts." Available at http://www.leanscm.net/Articles%20-%20May%20June%2003/Supply%20management.htm. Viewed 08/10/09.

- Strong organization skills to complete the various inspections, schedules, forms, and payment estimates that the contract requires.
- Strong communication skills to assist with communication between contractors, suppliers, the project team, regulatory agencies, and project stakeholders.
- The ability to make appropriate decisions in a timely manner.
- A broad-based understanding of the scope and requirements of the project.
- The ability to utilize root cause analysis techniques to determine the actual cause of problems and help in development of solutions.
- The ability to accept criticism gracefully and to provide criticism tactfully.
- The skill required to value the contributions of everyone who is a part of the project.

A wide variety of software exists to assist with the contract manager's tasks. In order to remain current with management tasks, whether completing them by hand or with one of the available contract management software programs, it is important for the contract manager to complete tasks on a regular basis. Failure to adopt an organized, scheduled approach to contract management can result in disaster for the project. If regular reports, payments, and work status checks are not conducted, problems can spiral out of control before they've even been identified.

5.1.8 How to Interact With Contract Personnel

In a perfect world, business operations would flow smoothly, according to contract requirements, and there would never be any contract disputes. Unfortunately, the business world has not reached perfection; and contracts are put in place to serve as a guideline for problem resolution.

.1 Contact-Related Communication

Very few business entities enter into a contract agreement with the intent to ignore the contract provisions. In order to ensure that the provisions of the contract are being addressed, frequent, regular communication must occur between all parties. Interaction with contract personnel should occur, at a minimum, under the following circumstances:

Prior to contract award to review contract requirements and ensure that both the contractor and contract manager have the same understanding of the scope of work.

At contract award to provide executed copies of the contract documents to all entities that are a part of the contract.

At regularly scheduled project update meetings to discuss the project schedule, contractor performance, and progress payments. It is much easier for all parties if variation from the contract is stopped at its earliest occurrence, or a change order is written before work is started, than it is to let work continue along the originally planned course without making necessary changes.

At regularly scheduled safety meetings to ensure safety practices are effective and being implemented.

Prior to contract close-out to develop a punch list of remaining work to be completed.

At project close-out to verify that all work has been completed in a satisfactory manner.

Recent news coverage and court activity regarding private businesses, publicly traded corporations, and governmental entities have highlighted the need to conduct business in an ethical manner or risk being the lead story on the evening news. Follow ethical business practices at all times.

.2 Contract Workers

With the desire for reduction in human resource expense, many functions that were once within the realm of a given corporation's workforce are now being outsourced to contract personnel. In many instances, contract personnel will work on-site for extended periods of time. Long-term association with contract personnel can lead to strong personal friendships between contract administrators and contract personnel. Avoid having a personal friendship or creating an environment where the ethics of either side are expected to be compromised. Favoritism should not be shown, nor should favors — either personal or business-related — be required as an implied part of any contract. All business dealings should be aboveboard, documented, and beyond reproach in order to protect all parties to the contract.

5.2 Funding Sources

Engineering projects can be funded in a number of ways, including:

Customer: Arrangements are made with the customer to reimburse the company based on various factors (e.g., time, materials).

Overhead: The cost of the project is absorbed over time by overheads built into sold goods and services.

Capital: Capital loans, sale of assets, new issue of shares, or profits from past company sales are used to cover cash expenditures.

5.2.1 How to Identify Available and Alternative Funding Sources

Companies finance their activities using a variety of methods. In many instances, they may be project or product specific, but some are relatively broad-based.

.1 Primary Funding Sources

Business funds are generated from the following sources:

Share capital: generated by investor funds. Ordinary shares are the most basic form of business finance.

Loans: funds borrowed from individuals or groups who want an agreed-upon return without taking on the risks related to ownership.

Convertible loan stocks: fixed interest loans issued with the agreement that they may be converted to share capital at a pre-specified date.

Leasing: a periodic rental paid for an asset that may or may not include eventual ownership.

Hire purchase: borrowing and assets combined in a single package.

Factoring debtors: a company receives a cash advance when handing over its debtors to a financial institution that specializes in debt collection.[104]

.2 Government Funding

Several sources of governmental funding exist. In order to determine opportunities for alternative funding, ask the following questions:

- Will the project create or retain jobs? Economic development grants may be available.
- Will the project utilize new methods of reusing/recycling items that currently enter the waste stream? Funds may be available for recycling.
- Will the project utilize disadvantaged business enterprises? Some additional funding may be available.
- Will the project require workers to learn new skills? Job training incentives may be available.
- Is the project to be located in an area that qualifies for special tax considerations? Tax increment financing (TIF) district considerations may apply.
- Can personnel costs be rebated through special programs that provide funding for businesses that employ a certain segment of the population?
- Does the municipality in which the project is located provide any economic development incentives, such as tax abatement, waiver of tap-on fees, or reduced permitting costs?
- Will public infrastructure improvements be a part of the project? The municipality, state, or federal government may provide a portion of the funding required.
- Can the project partner with a university? Interns may be available to serve at little or no cost to the project. (This won't be possible for projects that contain classified information or trade secrets.)

The local Chamber of Commerce or Economic Development agency is a good resource for sources of alternative funding. Most states and the federal government also have economic development departments. The services of a professional grant writer may be a justifiable project expense if the project qualifies.

---

[104] Dennis Lock, *Handbook of Engineering Management,* 2nd ed., Butterworth-Heineman Ltd, Oxford, England, 1993, p. 2227.

5.2.2 Knowledge of Financial Constraints

Regardless of what else a company's mission statements might say, all businesses exist to make money. It is, therefore, imperative that financial resources be used in the most responsible fashion possible.

In many instances, budgets are developed and available funds divided amongst its many items. In other instances, funding that has been earmarked for one type of expenditure cannot be used for any other expense, even if it produces a surplus in the area for which it was initially appropriated. This is especially true with municipal funding sources. For example, funds designated for capital equipment expenditures cannot be used for personnel expenses, even if the anticipated capital expense does not materialize and there is a deficit in the personnel fund.

Although a set amount of funding may have been allocated for the project, the entire amount may not be available at one time. A lag time may also exist between the time a payment request is submitted and the time that the funds are released — even for fully funded projects. In many instances, the time involved is significant. In gauging lag time, consideration must be given to document flow and review and approval procedures within the firm for various dollar levels of payment requests.

Some sources of funding, such as state and federal funding, come with strings attached. Carefully document how these funds are used. Most of these funds also require a program audit on a regular basis. Solicit the assistance of an internal or external resource who has been through the audit process before. Use assistance, especially with regard to extra documentation that may be required beyond what is defined in the funding agreement.

In the final analysis, financial constraints require managers to be creative. To avoid having activities locked down by constraints, explore alternatives such as altering project objectives, redefining parameters, and renegotiating partnerships. Use all applicable resources.

5.2.3 How to Develop Funding Proposals and Implement Funding Plans

Even tremendous new products and processes have to compete for the finite amount of capital available at any given time. In order to help ensure the successful funding of your project:

- Use the best marketing techniques available to "sell" the project benefits. The project team may have devoted a great deal of time to the project, but chances are that individuals making funding decisions have comparatively little knowledge of the value and intricacies of the project. Seize the opportunity to make your project the most interesting and desirable project seeking funding during that budget cycle.
- Become familiar with the nuances of company budgeting processes and preferences. If the budget year begins June 1, for instance, the initial budget projections are probably started by September of the preceding year. Make the request for funding during that initial planning phase. Waiting until the middle of May to ask for funding in a budget cycle that begins in June will probably sink the project, at least for that budget cycle.

When creating your funding proposal, consider the following:

- If there is a predetermined format for funding proposals, use it. Follow the rules!
- If there is no predetermined format, develop a business case for the project that is concise, clear, and easy to read.
- Define the problem the project will solve (no more than one or two short paragraphs).
- Explain possible solutions to the problem. (Remember to use the condensed version.)
- Explain why the chosen project is the best solution. (Hit the high points.)
- Show anticipated cost, expected *ROI*, and the time frame that will be required for the project.
- If the project will require funding of multiple phases, explain the rationale for the divisions between the phases.
- Use appropriate spelling and punctuation. Have someone who is unfamiliar with the project proofread the proposal. A fresh perspective enables the reader to uncover what may be lacking.
- Employ the talents of the best speakers on the project team if an oral presentation is required.
- Ask a member of upper management to review the proposal and serve as a champion for the project.
- Remember to thank the funding committee for their consideration at the close of your presentation. Handwritten thank you notes are relatively uncommon. Try sending one immediately after the meeting. If genuine in tone, they often have a powerful impact.

5.3 Financial Accounting and Budgeting Procedures

One of the most important financial activities for engineering managers is budgeting. Budgets serve many functions within organizations. They can:

- Provide an accurate timely analytical tool
- Offer a vehicle to predict performance
- Supply assistance in allocating resources
- Facilitate the ability to control current and ongoing performance
- Present early warning of departures from forecasts
- Offer early signals of oncoming opportunities or threats
- Force the organization to examine itself
- Function as a means of communication
- Reduce uncertainties
- Force managers to think in concrete terms[105]

[105] Robert Rachlin, *Handbook of Budgeting,* 4th ed., John Wiley and Sons, New York, NY, 2004, p. 1.1.

5.3.1 Knowledge of Budgeting Techniques

Budgets are planning tools — statements of the company's intentions that also represent a plan of action. Organizations differ in the specific formats and methods used. All aim to reflect the most realistic views of the upcoming period. Whatever the form, the results of the budgeting process always include projections of:

- Sales
- Expenses
- Resource requirements

Budgets usually cover periods of three months to one year and break down longer-term financial goals. Budget documentation, so often the focus of budgeting activities, is actually only one part of a very important and comprehensive process. The budgeting process itself is exceedingly effective because of the thorough analysis required and the range of individuals it involves.

.1 The Budgeting Process

Figure 5-1 shows the key steps in a budgeting process and represents activities both by engineering managers and individuals involved on the corporate level. Business divisions/units develop a strategy based on an analysis of their resources, the market for products, and the impact they estimate new products will have on business. Plans are then developed, taking into consideration past and current performance. This information is exchanged with and analyzed by corporate level reviewers in preparation for actual preparation of budgets.

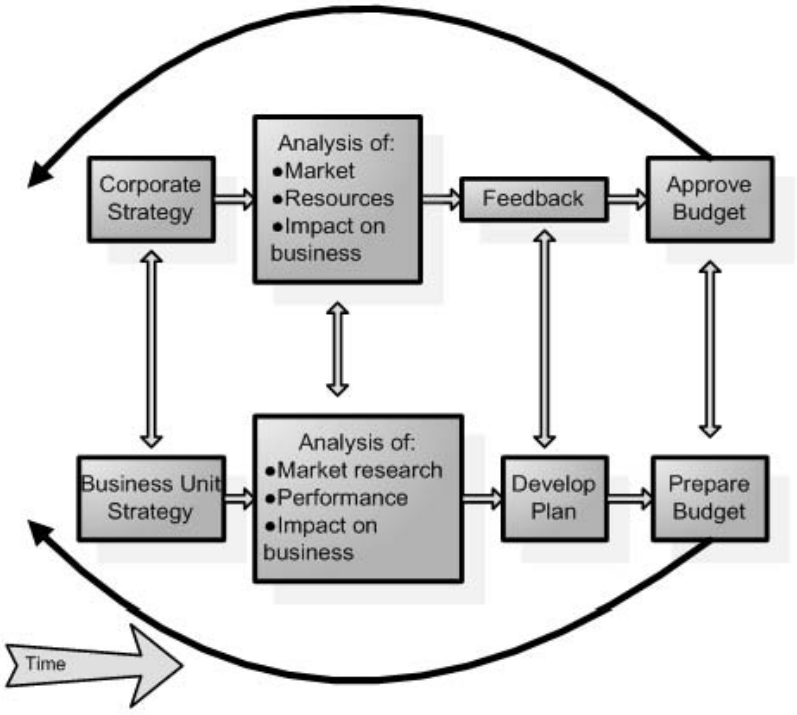

Figure 5- 1 Budget Flow Process

This figure also demonstrates the powerful combination of a "bottom-up" and "top-down" approach that facilitates effective communication among different levels of management. To be successfully implemented, budgets require:

- A well-defined organizational structure where all individuals are clear about their tasks and responsibilities
- Effective accounting procedures in place to develop and monitor budgets
- Management support from all levels to implement the budget
- Solid feedback and control procedures with associated corrective actions determined
- Flexibility — a willingness and ability to modify the budget as needs and circumstances change[106]

.2 Budgeting Activities

The elements of a budget vary from project to project and company to company. In general, thought, they include cost estimates (capital expenditures, direct costs, indirect costs, labor figures, materials, maintenance, sales, administrative overhead, etc.) that usually match the coding structure of the company chart of accounts.

Estimating costs can pose the following challenges:

- Omission of some costs in the assignment process
- Use of inappropriate methods for assigning costs across segments
- Assigning of costs to segments that are really common costs of the entire organization

Forecasting sales revenues involves using the best available data to make the most informed guesses. This may be achieved using qualitative methods (e.g., Delphi method, normative relevance analysis, scenario building, informed judgment) or quantitative methods (e.g., defining a series, exponential smoothing).

Develop budget documents so that users can identify:

- Activity included in the budget
- Resources being employed
- Results and measurements that can be anticipated from the budget
- Parts of the corporate plan that are satisfied (and to what degree) within this budget element, considering the funding proposed[107]

Communicate frequently. Involve all affected parties. Check that the budget as written is complete, reasonable, and acceptable to all. Give participants opportunities to voice their issues and concerns, look for areas of overlap, identify unstated opportunities, and declare their commitment to implementation.

[106] Fraidoon Mazda, *Engineering Management*, Addison Wesley, Harlow, England, 1998, p. 284.
[107] John Hampton, *AMA Management Handbook*, AMACOM Books, New York, NY, 1994, p. 6-12.

5.3.2 Knowledge of Alternative Budgeting Procedures

Approaches to budgeting vary according to company or project needs. Some of the most common alternatives include:

.1 Zero–Based Budgeting (ZBB)

As an alternative to traditional incremental budgeting, zero-based budgeting forces the managers to thoroughly re-evaluate their activities and determine whether activities should be ceased, minimized or expanded. Proponents of zero-based budgeting state that this is actually not a new concept but rather a traditional idea that is not currently practiced. ZBB is designed to address some of the challenges of common contemporary budgeting practices. The challenges include managers frequently padding budgets based on the assumption that they will be reduced by upper management. Budgetary problem areas and alternatives are difficult to assess and newer projects are often the first to be slashed as part of budget reduction.

Key elements: of a zero-based budget include:

- Identification of objectives
- Evaluation of alternative means of accomplishing each activity
- Evaluation of alternative funding levels
- Evaluation of work load and performance measures
- Establishment of priorities[108]

.2 Bracket Budgeting

In complex budget systems, the ways in which components of budget line items interact to change the bottom line are not always obvious. Bracket budgeting is achieved by creating a tactical budgeting model with a series of equations that show how the individual elements selected combine. This approach lends much needed transparency to the derivation of various line items in the budget.

.3 Budgeting For TQM

These budgets are designed to reflect costs associated with TQM efforts (setup, management, etc.). Advocates of this budgeting style do not think that traditional budgeting processes inherently promote excellence. Given that waste reduction and continuous improvement are central to the TQM process, TQM budgeting seeks to accommodate the efforts by revealing the actual costs of TQM activities and representing the cost savings and increase in profits gained as a result.

.4 Activity-Based Budgeting (ABB)

Activity-based budgeting shifts budgeting focus from costs to activities or business processes. Its goal, is to enable the budgeting process to address the need for continual process

[108] Robert Rachlin, *Handbook of Budgeting,* 4th ed., John Wiley and Sons, New York, NY, 2004, p. 27.3.

improvement. ABB is especially applicable in manufacturing firms with a diversity of products or processes. The key elements of ABB include:

- Type of work to be done
- Quantity of work to be done
- Cost of work to be done[109]

.5 Budgeting in Not-for-Profit Organizations

Not-for-profit organizations are growing at a tremendous pace. Because not-for-profit organizations are designed to be driven by motivations other than profits and measure their success differently, budgeting activities reflect a similar shift in orientation. Budgeting in the not-for-profit sector requires managers to carefully establish organizational objectives with clear and quantifiable success measures. Extra care also needs to be taken when associating revenues with the goods or services delivered.

Putting It Into Practice: What budgeting process have you utilized? What were some of the positive outcomes of the process? How will you approach budgeting differently next time?

5.3.3 Knowledge of Cash Flow Techniques and Requirements

Engineering projects occur over a period of time. It is extremely rare for the income for a project to be received by the company at the same time that expenditures are paid. Company financial managers will be looking for the engineering manager's assistance with managing the cash flow challenge by creating some form of communication, usually referred to as cash flow diagrams or schedules. Both document forms are simple and effective ways to represent the income and outflow of cash funds throughout the life of an engineering project.

.1 Cash Flow Diagrams (CFD)

Cash flow diagrams are drawn on a timeline that is divided into increments of months or years depending on project needs (see Figure 5-2). Income is recorded above the line and expenditures below.

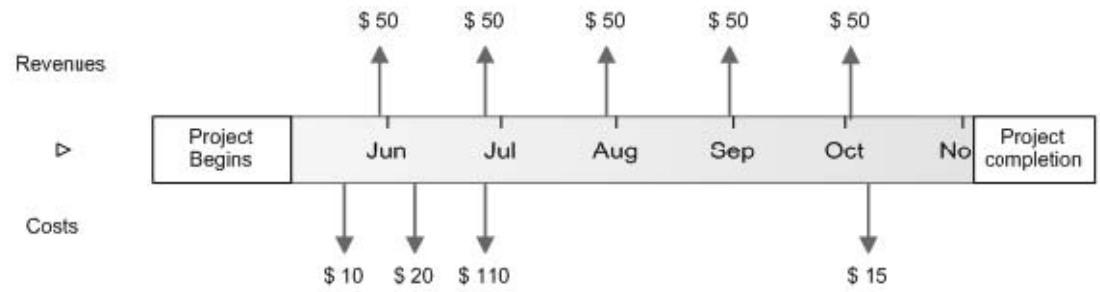

Figure 5- 2 Sample Cash Flow Diagram[110]

[109] Ibid, p. 31.4.

Usually these diagrams are completed based on natural categories or groupings (e.g., capital expenditures, materials inventory).

When managers are looking to view several dimensions of cash flow at a time, it is often more effective to create a "schedule" in a spreadsheet.

There can be significant lag time between the generation of revenues and the associated collection of cash or the incurrence of costs and the associated payments of cash. An electronic worksheet of cash flow allows the user to modify the data to determine the effects that changes in payment timing patterns will have.

.2 Cash Flow Schedules

Cash flow schedules (see Figure5-3) are created in spreadsheets. The rows represent periods of time (e.g., months, quarters) and the columns represent categories of receipts and expenditures (e.g., sales, prepayments, equipment maintenance). These are forecasting tools used to predict inflow and outflow of money and enable financial managers to prepare and implement effective cash flow strategies.

Month	Capital Costs	Materials	Maintenance & Repair	Admin
Jan	45,000			1,500
Feb		7,500		1,500
Mar			5,000	1,500
Apr		2,000		1,500
May	15,000			1,500
June			5,000	1,500
July				1,500
Aug		9,000		1,500
Sept			5,000	1,500
Oct				1,500
Nov		3,000		1,500
Dec			5,000	1,500

Figure 5- 3 Sample Cash Flow Schedule[111]

Expenditures are scheduled in the months that payments are due. When sizeable expenditures (materials, machinery, etc.) will occur before customer invoices will be paid, income from customer sales or payment schedules are also input. Rows/columns are totaled to reveal the estimated net losses or gains for each period. From this analysis, finance managers have a greater insight into actions to be taken.

---

[110] Donald Newnan, Ted Eschenbach, and Jerome Lavelle, *Engineering Economic Analysis,* 9th ed., Oxford University Press, New York, NY, 2004, p. 51.

[111] Ibid, p. 52.

For example, some engineering contracts may ask the company to invest a sizable amount of capital for expenses that are reimbursable and will not necessarily be included in the project budget. Nevertheless, they do require an expenditure of cash and must be addressed with planning.

There are several strategies that companies can use when a considerable outlay of funds is required, including:

- Customer can pay the supplier invoices directly
- Customer deposits funds in a purchasing fund
- Progress stage payments where funds are paid as the project achieves certain milestones[112]

Putting It Into Practice: How accurate have the cash flow estimates you have worked with been? How could they be improved? What resources will you use to help you develop cash flow documents?

5.3.4 Knowledge of Business Plan Fundamentals and Key Components

Traditional business plans are designed to represent the current state and future plans of a business entity to investors and other interested parties. Business plans contain:

- Executive Summary
- General Company Description
- Products and Services Management and Organization
- Marketing Plan
- Operational Plan
- Management and Organization
- Financial History and Analysis
- Financial Plan
- Appendices

Financial planning flows naturally as part of the strategic planning process. The two key *financial* elements of business plans are: (1) financial history and analysis, and (2) financial plan.

.1 Financial History and Analysis

Based on the assumption that solid analysis of the past precedes any serious attempt to forecast the future, financial plans include:

[112] Dennis Lock, *Handbook of Engineering Management,* 2nd ed., Butterworth-Heineman Ltd., Oxford, England, 1993, pp. 254-255.

- Financial history and ratios spreadsheet
- Debt schedule that supports information provided in financial statements
- Industry average ratios — sometimes input to enable useful comparisons

Supporting documents often found in appendices include year-end *balance sheets*, operating statements, business income tax returns for the past three years, and the most current balance.

.2 Financial Plan

The financial plan presents a reasonable estimate of the company's financial future. In these plans, company management communicates its vision, mission, goals, objectives, strategies, and values. This representation of the bigger picture is the foundation for developing budgets (sales, expense, capital) that will be used to fulfill the company business plan. While this is a labor-intensive effort, the process of analyzing data to create and evaluate possible solutions is extremely valuable.

An effective financial plan contains:

- Complete pro forma financial statement spanning several years
- The capital expenditures required to preserve or improve the competitive position of the company
- The financial objectives and benchmarks against which future performance will be evaluated
- Expectations for how the organization plans to obtain the financing required by the plan[113]

5.3.5 How to Evaluate Contents of Business Plans

Engineering managers familiarize themselves with various business planning instruments as a guide to their actions. A better understanding of overall plans leads to more effective implementation at all levels.

.1 Evaluating Business Plans

When evaluating financial plans:

- Investigate — Solicit information from individuals and teams involved in developing different portions of the plan.
- Reflect — Seek out the assumptions that formed the basis of the plan to better understand the plan's objective
- Confer — Discuss plans with coworkers and associates with differing perspectives
- Communicate — Share your thoughts about plans, especially if you believe you have identified an area of concern
- Infer — Be creative: Look beyond the numbers to what you can infer
- Seek action steps — What will it take to bring the plans to fruition?

[113] John Hampton, *AMA Management Handbook*, AMACOM Books, New York, NY, 1994, p. 6-3.

- Inquire — Reveal plan's deeper implications by asking yourself and others compelling questions
- Act — Act while remembering that business financial plans offer guidelines that are not written in stone

.2 Business Plans Are Management Tools

In addition to planning business activities, a business plan helps engineering managers track, monitor, and evaluate progress. Business plans are used to establish timelines and milestones. Review plans at least monthly to ensure that you are progressing in accordance with goals. Some plans will include commentary about alternative options, identify possible obstacles to achievement, and offer solutions. Refrain from relegating planning documents to an obscure shelf in the office. Keeping plans in sight and in the front of the manager and team members' minds greatly increases the likelihood of success.

Putting It Into Practice: How will you involve employees in the business planning process? What obstacles will you encounter, and how will you overcome them?

5.3.6 How to Interpret Balance Sheets and Income Statements (P&Ls)

Two key financial summary documents are created as a result of company accounting processes: balance sheets and profit and loss statements — frequently referred to as P&Ls. The objective is to reveal results of operations over a period of time and the financial position of the company at a point in time.. These are useful, but limited, tools. For example, they are only representations of quantifiable monies. Intangible assets like goodwill, quality and experience of employees, market positioning, product/service quality, etc., are difficult to quantify and are not included. Remember also that these financial statements are historical representations and are not designed to project future possibilities of the company.

.1 Balance Sheets

Simply put, a balance sheet demonstrates that the difference between a company's assets and its liabilities is retained by the company as equity. This is represented by the formula:

Assets = Owner's equity + Liabilities

In corporations the owner's equity includes the owner's amounts paid in to obtain capital stock whatever funds have not been distributed to shareholders (retained earnings).

Balance sheets are created by using a double entry system — every activity must be recorded in a fashion so that the balance sheet equation remains in balance. The purpose is to be able to view financial activities from two differing perspectives to describe value received for cost expended, benefits received for sacrifice, etc.

The key components of a balance sheet are shown below in Figure 5-4.

Assets	Liabilities
▪ Fixed assets ▪ Current assets	▪ Capital ▪ Long-term liabilities ▪ Current liabilities

Figure 5- 4 Balance Sheet Components

Fixed assets will not be converted to cash within the year (machinery, buildings, vehicles, etc.) These support the revenue generating activities of the firm.

Current assets will be used or converted to cash or consumed within the year (cash on hand, stock, prepayments from customers, work in progress, etc.).

Capital is the contributed capital of the shareholders plus the retained earnings and is the residual of assets in excess of liabilities.

Long-term liabilities do not need to be paid in the current year (loans, mortgages, bonds, etc.)**.**

Current liabilities are scheduled to be paid in the current year (payments due to suppliers, payroll expenditures, etc.).

A balance sheet will reveal the company's financial position on any given day in terms of assets and liabilities and owners' equity. It is through looking a series of balance sheets (quarterly, annually, etc.) that the reader can form some conclusions about the operations of a company.

.2 Income Statements — Profit and Loss Statements (P&Ls)

P&L statements are designed to show the reader the results of business operations for a given period of time. The equation for P&L statements is:

Net Income = Revenue – Expenses

Figures on P&L statements can be represented in numerous categories and formats. An example of an income statement is shown in (Figure 5-5)

Revenue	Year-to-Date	
	Amount	% of Sales
Gross Sales		
Less sales returns and allowances		
Net Sales		
Cost of Sales	Year-to-Date	
	Amount	
Gross Profit	Year to Date	
	Amount	
Operating Expenses	Year to Date	
	Amount	% of Sales
Selling		
Salaries and Wages		
Commissions		
Advertising		
Depreciation		
Total selling expenses		
General/Administrative		
Salaries and Wages		
Employee Benefits		
Payroll Taxes		
Insurance		
Rent		
Utilities		
Depreciation and Amortization		
Office Supplies		
Travel and Entertainment		
Postage		
Equipment maintenance and rental		
Interest		
Furniture and equipment		
Total General/Administrative Expenses		
Total Operating Expenses		
Net Income before Taxes		
Taxes on Income		
Net income after taxes		
Extraordinary gain or loss		
Income tax on extraordinary gain		
Net Income (Loss)		

Figure 5- 5 Profit and Loss Statement Elements

Revenue is the increase in shareholders' equity created by all income-generating activities (e.g., product sales, maintenance services).

Cost of Goods Sold is the cost of merchandise purchased for resale or cost of manufactured items that are sold during the period. Only applies to merchandisers or manufacturers.

Depreciation Expense is separated because it is not a cash expense, but instead represents the allocation of costs of fixed assets to periods they give rise to revenues. As a noncash expense it is important in cash budgeting and capital budgeting.

EBIT or operating income is earnings before interest and taxes and is a measure of how well the company can pay fixed interest costs.

Dividends are not income statement items, but are included to show the growth of retained earnings for the period.

Remember that, especially in manufacturing, P&L statements may be misleading, because costs incurred for goods produced or services rendered can be included on statements in one period, but the associated income will not be reflected until a later period. The revenues from P&L statements are used to create the balance sheet.

5.4 Engineering Economic Analysis Techniques

Engineering economic analysis: The basic goal of any investment is to maximize the return on the investment. Engineering economic analysis provides for a systematic use of engineering economic tools for evaluating investment opportunities and for ranking competing investments.

- The problem is significant enough to justify giving it serious thought and effort
- The problem is complex enough to prevent working it out mentally; a careful, organized approach to the analysis of the problem is required
- The problem has economic aspects that are important to reaching a decision[114]

Engineering economic analysis helps managers determine a number of things (e.g., priorities, design parameters, financing issues).

5.4.1 Knowledge of Engineering Economic Analysis Techniques Such As NPV and ROI

Financial analysis looks at a business performance in relationship to several important business factors, including:

- Liquidity
- Profitability
- Activity
- Capitalization

An additional goal of financial analysis is to determine whether a given project merits the funding requested and will be a good business endeavor. In order to achieve this analysis a set of techniques are used.

[114] Donald Newnan, Ted Eschenbach, and Jerome Lavelle, *Engineering Economic Analysis,* 9th ed., Oxford University Press, New York, NY, 2004, p. 5.

.1 Net Present Value (NPV)

Net present value (NPV) is used when creating capital budgets to determine whether an investment or project will be profitable. It is calculated by finding the difference between the present value of cash inflows and the present value of cash outflows and uses the following formula:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

where:

t = the amount of time (usually in years) that cash has been invested in the project

T = the total length of the project

r = the cost of capital

C = the cash flow

C0 = the initial investment

NPV looks at the value of dollars today and compares them to the value of dollars in the future, taking into account both inflation and returns. Implement a positive NPV project and reject or redesign when a negative NPV is assessed.

.2 Return on Investment (ROI)

Return on investment (ROI) is calculated by the formula:

ROI =

Net to Operatng Income (income before taxes and interest)

divided by

Average Operating Assets (e.g., inventory, accounts receivable cash)

ROI tells a company how much was profit to cost saving was realized from a project. While a useful tool, it does have limitations. Managers can inherit costs over which they have no control, and ROI calculations can sometimes be a disincentive to managers whose compensation is based on ROI. Using a balanced score card analysis in combination with ROI is considered favorable, because it helps managers understand how to achieve an increase in ROI.

.3 Net Present Value Analysis

In order for companies to compare alternatives, they must be assured that the values being compared are being represented in equivalent terms, which is known simply as present value analysis.

.4 Rate of Return Analysis

Rate of return analysis is commonly used in industry. The advantage is that managers can compare a "single feature of merit that is readily understood."[115] This analysis requires companies to develop two calculations:

Internal rate of return (IRR): The interest rate at which the net present value of the project is zero(the present value of cash inflows exactly equals the present value of cash outflows)

Minimum attractive rate of return (MARR): The rate determined by managers to be the goal. This is essentially the cost of capital for the firm

To make decisions between alternatives investments:

- When the IRR is greater than the MARR, choose the higher cost alternative
- When the IRR is less than the MARR, choose the lower cost alternative.

.5 Incremental Analysis

When companies need to compare alternative investments, incremental analysis provides a method to determine when differential costs are justified by differential benefits.

.6 Economic Value Added (EVA)

Economic value added (EVA) is especially useful in companies that are considered to be asset intensive. The primary advantage to using EVA is that it might encourage managers to increase their focus on activities and investments that increase the company's value. It is used by several leading companies, including Wal-Mart and the U. S. Postal Service.[116]

It is calculated using the formula:

EVA = NOPAT – WACC x (Capital Deployed)

where

NOPAT = Net operating profit after tax (net income)

Capital Deployed = Total assets – Current liabilities

WACC = Weighted average of cost of capital (equity and debt) employed in producing the earnings

---

[115] ibid., p. 212.

[116] C.M. Chang *Engineering Management: Challenges in the New Millennium*, Pearson Prentice Hall, Upper Saddle River, NJ, 2005, p. 208.

5.4.2 How to Interpret and Apply the Results of Engineering Economic Analyses

Given the multitude of financial analysis methods, the challenge for managers is "What do I do with this information?"

.1 Balanced Scorecard

The *balanced scorecard* is a measurement and management system combined. It gives managers a way to take financial data and apply it to strategic planning in a very practical manner. It was developed in the early 1990s by Drs. Robert Kaplan (Harvard Business School) and David Norton.

The balanced scorecard (see Figure 5-6) recommends viewing the company's four perspectives—Financial, Customer, Internal Business Processes and Learning and Growth- Adding nonfinancial data to the traditional financial data provides a more comprehensive approach to strategic planning. The strategic plan of the organization is converted into an action plan. It helps to identify what should be done and what needs to be measured.

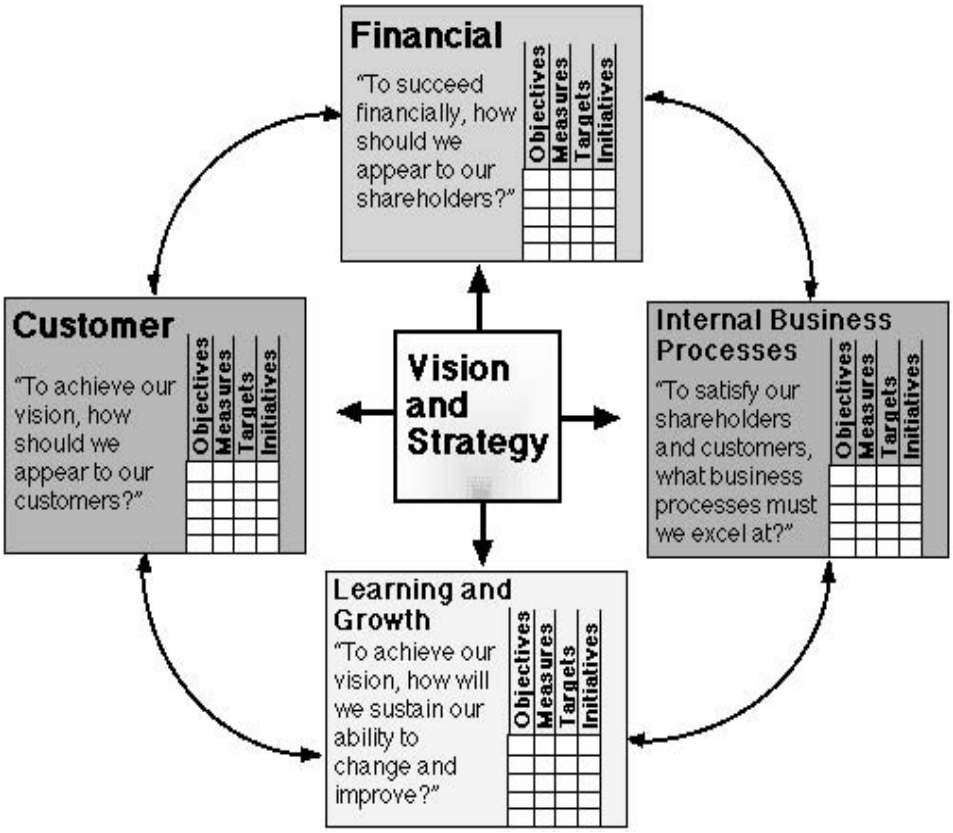

Figure 5- 6 Balanced Scorecard[117]

[117] Paul Arveson, "What is the Balanced Scorecard?" Available at http://www.balancedscorecard.org/basics/bsc1.html. Viewed 08/10/09. Diagram used with permission of The Balanced Scorecard Institute.

.2 Choosing Among Options

While it would be pleasant to be able to implement every project that economic analysis deems worthwhile, the reality is that companies have limited resources. Frequently managers are forced to choose among an array of alternatives. When comparing projects, develop a ranking system based on the chosen method(s) of analysis. Using this tool, projects may be commissioned until money or other resources are depleted. Naturally, these analyses are best revisited on a regular basis — taking into consideration that capital budgets are fairly inflexible. Once a commitment has been made to implement a project, be sure to follow through.

Putting It Into Practice: Which of the economic analysis techniques discussed have you used? What other techniques have you found effective? How do you use economic analysis to improve your job performance and project success measures?

5.4.3 How to Calculate Economic Equivalence, Inflation, Purchasing Power of Money, and Estimation of Costs

.1 Economic Equivalence

Equivalence uses mathematical calculations to determine the equivalent value of payments made at a given point in time. When companies receive or pay monies over a period of time, agreed-upon finance charges are usually assessed (e.g., interest, bonus payments). If the receiver of monies did not care when they received funds, there would be no need for equivalence calculations. Because cash flow is a key financial issue, companies will often desire a calculation that can be used to evaluate different financial arrangements and make sure that the money received by the company at any given point in time will be equivalent. Equivalence calculations involve interest formulas.

Traditionally, the following notation is used:

- i = interest rate per interest period. In the equations the interest rate is stated as a decimal (that is, 9% interest is 0.09)
- **n** = number of interest periods
- **P** = a present sum of money
- **F** = a future sum of money. The future sum F is an amount, n interest periods from the present, that is equivalent to P with interest rate i

To calculate the future sum of money, use the formula:

Future sum = (Present sum) $(1 + i)^n$

or

$F = P(1 + i)^n$

.2 Inflation

The simple reality is that inflation makes future monies less valuable than current monies, which, in turn, impacts a company's purchasing power. Because of the need to calculate equivalencies when conducting engineering economic analysis, inflation must also be taken into consideration.

To capture true equivalence, analysis uses the market interest rate. To calculate this amount using the formula below, it helps to understand three terms:

Inflation rate (*f*): The inflation rate captures the effect of goods and services costing more — a decrease in purchasing power of dollars. The inflation rate is measured as the annual rate of increase in the number of dollars needed to pay for the same amount of goods and services.

Real interest rate (*i* '): This rate measures the "real" growth of money, excluding the effect of inflation. This is sometimes called the inflation-free interest rate.

Market interest rate (*i*): The rate of interest that one obtains in the general marketplace. The lending rate for autos and boats is also a market rate. This rate is sometimes called the combined interest rate, because it incorporates the effect of both real money growth and inflation.

To calculate the market interest rate that factors in inflation:

$$i = i' + f + (i')(f) \text{ Purchasing Power of Money}$$[118]

The purchasing power of money is directly related to inflation because when prices inflate, less can be bought with the same amount of dollars. Hence, inflation causes a loss in purchasing power.

.3 Estimation of Costs

Costs are estimated usually by one of three methods:

Grouping: Members of different teams meet to estimate costs based on past experience. This is a quick and low-cost option that is also less accurate.

Comparison: Based on data from previous experience that are similar to future activities. Cost parameters are modified and calculated.

Detailed estimating: Involves (1) calculating use of materials, design time required, sequence of operations and labor required; and (2) lists subcontractor work, equipment, and tooling and test equipment requirements.[119]

---

[118] Donald Newnan, Ted Eschenbach, and Jerome Lavelle, *Engineering Economic Analysis,* 9th ed., Oxford University Press, New York, NY, 2004, p. 140.

[119] Dennis Lock, *Handbook of Engineering Management,* 2nd ed., Butterworth-Heineman Ltd., Oxford, England, 1993, pp. 259-260.

There is a direct correlation between the cost of estimation and the accuracy of estimation. Be sure to invest in more detailed estimations for larger and more expensive projects.

Putting It Into Practice: Have you ever been involved in a project where inflation and equivalence costs were not assessed? How did management address the situation once it was discovered? What can you do to avoid repeating this experience?

5.5 Inventory Control Procedures and Supply Chain Management

5.5.1 Knowledge of Supply and Usage Procedures Such As JIT

Supply chain management practices evolved dramatically in the later half of the 20th century. The traditional supply management culture, where there was little integration between departments had a narrow focus on production and failed to consider the overall impact of supply decisions on all of the business's resources and functions.

.1 Just-in-Time (JIT)

Since the early 1980s, *just-in-time (JIT)* processes have been revolutionizing supply management. Inventories once kept around "just in case" were now considered liabilities to company operations. Maintaining high inventories drains resources and wastes both time and space. Alternatively, JIT demanded:

- Lean Inventories — minimizing costs related to managing, handling, and storing a large range and volume of materials
- Speed — inventories held by the company measured by hours rather than days or months
- The right stock at the right time — carefully managing flow of supplies, so that production staff have what they need on time but not ahead of time

There is, of course, an increased risk that the company will experience delays getting products to customers if supplies are not available or delivered on time. JIT procedures include strategies to reduce the likelihood of this occurrence.

Developing close-working relationships with suppliers is key to the success of JIT operations. Success depends on the company's ability to foster relationships with high-quality suppliers who produce superior goods and respond quickly and effectively to requests.

.2 Materials Resource Planning (MRP)

As companies gained access to increasingly powerful computing, materials resource planning (MRP) software applications were developed to address the ordering and scheduling of materials — dramatically easing the process. MRP software was limited though, in that it was focused on production and was not designed to integrate the management of all the resources, information and functions of the business.

.3 Manufacturing Resource Planning (MRPII)

With increasingly sophisticated software applications, MRP evolved beyond the supply silo and developed a more integrated business function approach. This development, which facilitates interaction among several business units, is commonly referred to as MRPII.

A great leap forward, the MRP integrated business system:

- Provides visibility into material requirements and capacity driven from a desired operations plan
- Allows detailed input of activities
- Translates all this activity to a financial statement
- Suggests actions to address those items that were not in balance with the desired plan.[120]

Key limitations of MRPII:

- Calculations are based on forecasting — which is inherently error prone
- MRP applications tend to assume the production facility has unlimited capacity — which it does not. Material backlogs can present significant challenges to the system[121]

.4 Enterprise Resource Planning (ERP)

Rooted in MRP, *enterprise resource planning (ERP)* evolved primarily due to:

- Further expansion in technological capabilities
- A culture shift in supply chain management, a significant change in expectations, demanding faster responses
- A business model shift from labor-intensive (company *makes* components) to materials-intensive (company *buys* components)[122]

ERP software seeks to integrate information across the company and to automate as many basic functions as possible (see Figure 5-7).

The broad scope of ERP application functions now includes:

ERP Functions	
• Capacity requirement	• Cost management
• Engineering/product definition	• Financials and accounting
• Human resource management	• Manufacturing processes
• Material bills and routing	• Order management
• Real-time planning and scheduling	• Purchasing and inventory

Figure 5- 7 ERP Software Functions

[120] James Ayers, *Handbook of Supply Chain Management,* St. Lucie Press, Boca Raton FL, 2000, p. 170.
[121] ibid., p. 54.
[122] ibid., p. 169.

Response times are dramatically reduced. Forecasted material needs can be easily compared to existing stock and orders already placed — making the adjustment of orders a much simpler process. Program features also enable managers to simulate alternate scenarios as part of their planning process.

5.5.2 Knowledge of Inventory Control Software

.1 Software Application Categories

Numerous applications are available today that have been designed specifically for supply chain management, grouped into the following categories.

- **Supply Chain Management (SCM) or Advanced Planning and Scheduling (APS) —** emphasizes supply and demand planning throughout the supply chain (when more than one company is involved). A benefit: the ability to share forecasts.
- **Manufacturing Execution Systems (MES) —** focuses on automating scheduling activities to run production centers. A benefit: useful for complicated production settings where speed is important.
- **Warehouse Management Systems (WMS) —** designed to address the needs of distributions centers and fulfillment issues. A benefit: bar coding and real time inventory status.
- **Customer Relationship Management (CRM) —** focuses on the customer interface and addresses customer service, contact management, and data mining in order processing. A benefit: especially useful for e-commerce.
- **Product Data Management (PDM) —** enables concurrent engineering by addressing needs of companies looking for standardized ways of exchanging product information (e.g., fast-paced technical companies). It also facilitates various communication needs with supplier partners. A benefit: streamlined design and development communication.

.2 Purchasing Decisions

Because the company is likely to be working with whatever software application is chosen for quite some time, be careful with selection and purchasing practices.

Application Purchasing Suggestions:

- Several software categories can overlap — company mergers lead to the creation of so-called integrated packages. Watch out for general language and marketing ploys.
- Let skilled professionals handle the negotiation process. Focus on necessary features and avoid being caught up in the frills.
- Plan for problems — they will occur.
- Establish an evaluation system that weighs application features and benefits.
- Read betwedaen the lines — consider what is *not* being said.
- Pay attention to ongoing service and maintenance arrangements — you will need them.
- Do your homework — check service provider and product quality.

5.5.3 How to Monitor Inventory and Ensure Sufficient Supplies

When supplies and products languish at the production facility, they drain resources. With the business model shift from producers-of-product to assemblers-of-products, focus must go to managing the entire supply chain. No company functions in isolation and maintains its competitive edge.

Inventories flow best when:

- Team members at all levels are empowered to act quickly
- Alternative suppliers and contingency plans are in place
- Companies practice what they preach and don't ask suppliers to do what they won't do
- Suppliers have implemented similar culture shifts and work with smaller, more frequent lots
- Progress is tracked carefully
- Performance measurements are shifted from indicators like ROI to yield improvements and manufacturing cycle time
- Companies invest in meeting training needs.
- Greatest hurdles are located and tackled first

To maximize relationships with suppliers:

- Reduce supplier lead time by offering financial incentives
- Develop stable forecasts
- Use blanket orders
- Authorize partial builds
- Use local sources when possible to minimize transportation issues
- Encourage small, frequent shipments[123]

.1 Five Tasks for Effective Supply Chain Management

Looking from another perspective, James Ayers, an expert in economic systems planning, offers this approach to supply chain management:

- Design supply chains for strategic management
- Implement collaborative relationships
- Forge supply chain partnerships
- Manage supply chain information
- Remove cost from the supply chain[124]

[123] Keki Bhote, *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer –Supplier Partnership,* AMACOM Books, New York, NY, 1989, pp. 363-365.

Review

Upon completing the study of *Domain 5: Financial Resource Management,* you should be able to answer the following questions:

1. Identify at least five traditional contract elements. Discuss what each is designed to accomplish.
2. What are the advantages to working with Uniform Contract Format (UCF)?
3. What strategies are wise to employ when interpreting contracts? Explain the benefits of each.
4. How can seeking government funding be advantageous to a company? Where can you go to conduct research on funding opportunities?
5. Describe some of the do's and don'ts of creating funding proposals.
6. Why is a combination of a bottom-up combined with a top-down approach to budgeting usually most effective?
7. Why is it important for an engineering manager to work with cash flow graphs and diagrams?
8. Explain how balance sheets and income statements (P&Ls) are used to express the status of a company at any given time. What do they communicate?
9. Explain NPV and ROI. How do they help determine the success of a project or company?
10. What are the objectives and advantages to the balanced scorecard approach to economic analysis?
11. Discuss the features of JIT, MRP, MRPII and ERP. What contributions have these approaches made to supply chain management?
12. Discuss the benefits of current inventory management software applications. What steps should companies take when selecting the most useful package(s)?

For Further Information

A Practical Guide to Statistical Quality Improvement Opening up the Quality Toolbox (1992) by Michael R. Beauregard, Raymond J. Mikulak, and Barbara A. Olson is a great reference book that includes user-friendly, practical explanations of many statistical tools.

[124] James Ayers, *Handbook of Supply Chain Management,* St. Lucie Press, Boca Raton, FL, 2000, p. 54.

Domain 6: Marketing, Sales and Communications Management

Domain Champion: Darryl Mohan

6.1 Sales and advertising practices

- 6.1.1 Knowledge of U.S. practices
- 6.1.2 Knowledge of global practices
- 6.1.3 Developing and implementing a sales and advertising plan

6.2 Customer satisfaction strategies

- 6.2.1 Knowledge of techniques to obtain reliable measures of customer satisfaction
- 6.2.2 Analyzing current levels of customer satisfaction and recommending strategies for improvement

6.3 Marketing and branding techniques

- 6.3.1 Knowledge of techniques
- 6.3.2 Applying the techniques, interpreting the results, and making appropriate recommendations
- 6.3.3 Communicating recommendations to non-marketing personnel
- 6.3.4 Developing and promoting brands

6.4 Product portfolio analysis

- 6.4.1 Analyzing a current product portfolio
- 6.4.2 Evaluating the appropriateness of the portfolio based upon competition, technology and market forces, and making recommendations

6.5 Global trade and international operations

- 6.5.1 Knowledge of global trade and international operations
- 6.5.2 Knowledge of cross-cultural management differences
- 6.5.3 Interacting with managers in other cultures

6.6 Pricing strategies

- 6.6.1 Knowledge of current pricing strategy,
- 6.6.2 Evaluating the appropriateness of the pricing to the competition, technology, and market forces
- 6.6.3 Communicating the impact of pricing on marketing strategy

Domain 6 Marketing, Sales and Communications Management

Key Words and Concepts

Advertising	Mass media communications of a specific message (or set of messages) to potential buyers
Boston Matrix	Model used to describe a product in relationship to its levels in market share and market growth
Branding	Establishing a product "identity" that customers associate with various product qualities (quality, price, service, image, etc.) and which creates value in customers' minds
Marketing	Strategies and activities that focus on assessing the needs and wants of potential customers and then meeting those needs
Market Segmentation	Dividing the market base into homogenous groups in order to strategically target market activities
Product Life Cycle	The stages that products progress through from development to removal from the market
Product Portfolio	The range of products a company has in development or available for consumers at any one time
Sales	Strategies and activities that focus on the attempt to motivate potential customers to purchase a product or service

6.1 Sales and Advertising Practices

While *sales, marketing,* and *advertising* are part of the same "system," they are distinct in their aims:

- Marketing: focuses on assessing the needs and wants of potential customers and then meeting those needs.
- Sales: focuses on the attempt to motivate potential customers to purchase a product or service.
- Advertising: focuses on communicating a specific message or set of messages to buyers.

Together, the goal of marketing, sales, and advertising is to get a needed or wanted product or service to a customer at a price they are willing to pay, while maintaining a profit for the company.

Fundamental advertising principles are universal. When applying them internationally, however, actual advertising practices must be responsive to the specificity of local markets.

6.1.1 Knowledge of Advertising and Sales Practices

.1 Advertising Process

Advertising has five key objectives:

1. Create interest in the product (new customers, new/larger orders, etc.)
2. Improve company visibility and image (brand recognition, etc.)
3. Differentiate product from competitors' products
4. Promote special events (sales, new product introductions, etc.)
5. Support sales efforts

While part of a larger marketing process, advertising production activities follow a relatively straightforward process. Whether facilitated by in-house staff or through external contractors (advertising agencies, etc.), the process includes:

- Identifying the target audience and determining its key characteristics
- Selecting the media (TV, newspapers, print, web-based, etc.)
- Selecting the advertising message by crafting communication goals
- Producing content by crafting and combining text, visuals, auditory elements, etc.
- Positioning the advertisement while strategizing about: the frequency with which the message will be viewed, the size of the message, all while remaining within cost parameters (see Figure 6-1).

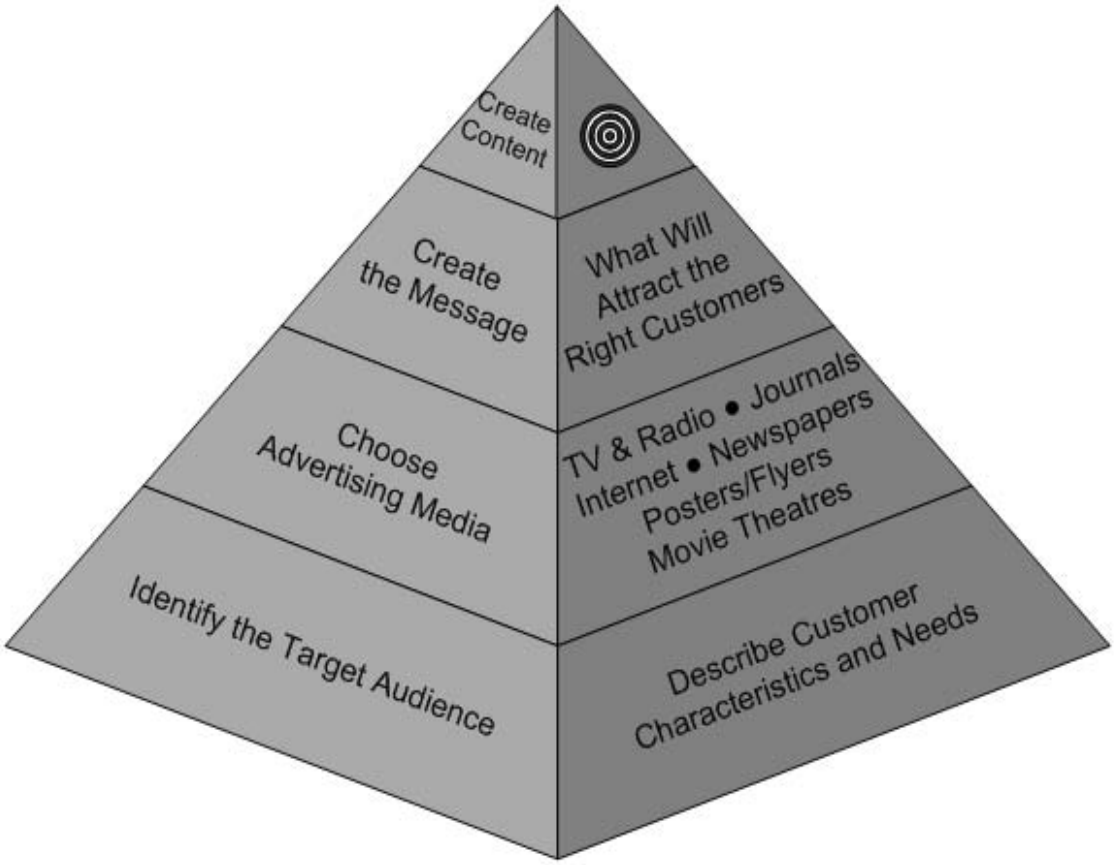

Figure 6- 1 Producing Advertising

Advertising is presentational in nature — it is a one-way communication from the company to the buyer. In contrast, sales is an interaction (or series of interactions) between the company and the buyer.

Figure 6- 2 Sales Process Steps

Putting It Into Practice: Describe how your job duties relate to the sales process. What do you do that directly or indirectly impacts sales?

6.1.2 Knowledge of Global Practices

When developing or executing a global marketing plan, sales and advertising staff must be mindful of the challenges they face when working in a variety of different cultural environments. The following sections outline those challenges, as well as the skills required to manage them.

.1 International Marketing Challenges

Marketing challenges that present themselves can involve any combination of:

- Multi-national issues
- Multi-cultural issues
- Multi-linguistic issues

To be competitive in today's marketplace, companies must be responsive to both local and global market conditions. Numerous studies examining issues related to marketing internationally (skills, practices, etc.) have been conducted in recent years. Organizations are demanding that managers further develop their international business skills. In fact, many organizations consider global marketing skills to be their most pressing training need.

.2 Marketing Skills for International Managers

Ten marketing skills determined to be of greatest need for managers working in the international market place are:

1. Assess suitability of product to foreign markets
2. Adapt to foreign business practices, cultural differences and protocol
3. Negotiate effectively in a multicultural setting
4. Identify, evaluate, qualify, and select foreign distributors/agents/EMC/etc.
5. Communicate clearly with others when English is not their first language
6. Develop promotional/presentation materials/product literature
7. Determine appropriateness of product adaptation versus standardization (e.g., using local language on product packaging)
8. Assess foreign market size and potential
9. Evaluate and select appropriate foreign market entry alternatives
10. Evaluate and select international pricing strategies[125]

[125] Ralph F. Jagodka, "Skills Needed for Effective International Marketing: Training Implications," 1998. Available at http://marketing.about.com/gi/dynamic/offsite.htm?zi=1/XJ&sdn=marketing&zu=http%3A%2F%2Fglobal edge.msu.edu%2F. Viewed 08/10/09.

6.1.3 Developing and Implementing a Sales and Advertising Plan

.1 Advertising Plans

The advertising plan must derive from the marketing plan, goals and activities. It includes identifying the target audience for the product or service, the actual positioning of advertisements and concludes with the evaluation of program success. Employing advertising agencies or other advertising consultants often is advantageous because of the expertise and alternative perspectives they bring to the process. Whether advertising is facilitated by internal departments or by external advertising agencies, the process is essentially the same. After creating the plan, be sure to double-check before making presentations to key decision makers.[126]

Checklist for advertising plans:

- Is research about target audience(s) thorough and complete?
- What is the advertising schedule, and will it meet the buyers' needs/interests? Is seasonality an issue? Will advertising appear in shorter bursts or over longer periods of time?
- Can optimal frequency be achieved within budget constraints? Are funds being used wisely?
- Can advertising efforts be maximized by *partnering* with other business units, trade associations, or others? [127]
- Does the plan allow for smaller market testing before rolling out larger campaigns?
- Are success measurements predetermined? What results are you looking for?

.2 Sales Plans

Each sales plan will be unique to the industry and products being sold. Figure 6-3 lists key elements that most plans share.

---

[126] For more information on creating marketing plans, goals and strategy, see *Harvard Business Review* article 9 579 054, "Marketing Strategy - An Overview," Professor E. Raymond Corey, 1978, Publishing Division HBR.

[127] For additional information on how companies should prospect and conduct themselves within partnerships, see: "Is Your Strategic Alliance Really a Sale?" Joel Bleeke and David Ernst, 1995, Publishing Division HBR, and "Simple Rules for Making Alliances Work," Jonathan Hughes and Jeff Weiss, 2007, Publishing Division HBR.

Key Elements of a Sales Plan

- Overview of sales plan and strategy
- Customer retention and loyalty plans
- Sales force organization
- Prospect management and lead system
- Sales activities timetable
- Sales tracking system description
- Sales effectiveness summary

Figure 6- 3 Sales Plan Elements[128]

Sales plan development can be approached in many ways, including:

- **Top-down (market potential):** Data from a variety of sources regarding market trends, growth, and research estimates are brought together to create sales estimates
- **Bottom-up:** Marketing and sales staff create estimates of what they will sell in the future based on past accomplishments and review their current/possible customers and opportunities
- **Resource-based:** An analysis based on available human, financial, technological, and other resources

The most comprehensive sales plans are formed using a variety of these approaches. Other things to consider when developing the plan:

- Product supply and demand
- The organization's strategic objectives
- Resource allocations such as finances or labor

Sales plans should be reviewed regularly (e.g., monthly, quarterly, etc.) and assessed to determine effectiveness. Plan adjustments should be made as needed.

.3 Sales Engineering

For more complex products, some organizations employ a sales engineering process. As with other sales processes, the objective of the process is to sell as much product as profitably as possible. The only difference is that a sales engineer with extensive knowledge of the product and exceptional communication skills is employed as part of the sales process.

The role of the sales engineer is two fold. On the one hand, he utilizes his engineering expertise to provide accurate information and effective solutions to his customers. On the

[128] Sales Plan Template. Available at http://www.ideabridge.com/ideabridgecom/whitepapers_sales.asp. Viewed 08/10/09.

other hand, he collects product feedback from customers and shares it with the product development and marketing staffs. They, in turn, use the collected intelligences for strategic planning, product re-engineering, feature development and so on.

Putting It Into Practice: To what extent have you contributed your engineering expertise to the sales process? Are you called on to speak with customers? How have you brought what you discover in those conversations to your engineering process?

6.2 Customer Satisfaction Strategies

Customers today are more informed, more sophisticated and more demanding. They are looking for improvements in effectiveness, efficiency, and integration of products and services, such as:

- Speed of customer service
- Customer self-service
- Integrated solutions
- Customized service and sales
- Consistent and reliable service
- Flexible fulfillment and convenient service
- Transparent sales process
- Continuous improvement in customer service
- • Technology-enabled services[129]

Why collect customer satisfaction data? Satisfied customers:

- Stay longer and make subsequent purchases
- Say positive things about the company and potentially bring in other customers
- Tend to spend more money when they are pleased

6.2.1 Knowledge of Techniques to Obtain Reliable Measures of Customer Satisfaction

Customer satisfaction measurement, analysis, and implementation is so critical that ISO 9000 standards now require companies to assess customer satisfaction. Fortunately, companies are left to determine on their own the assessment process.

.1 Tools: Surveys and Questionnaires

Well-crafted questionnaires and surveys are strategically developed to collect specific customer satisfaction data useful to the organization. Two types of customer satisfaction surveys are:

[129] C. M. Chang, *Engineering Management: Challenges in the New Millennium,* Pearson Prentice Hall, Upper Saddle River, NJ, 2005, pp. 471-473.

- **Relationship-oriented:** focus on the nature of the business/customer relationship
- **Transaction-oriented:** seek information on customer satisfaction with specific transactions

While survey content varies from company to company and product to product, experts stress that the goal of any customer satisfaction survey should be to determine what customers will actually *do*. While it is important to know if customers are satisfied with a product or service, it is equally important to gauge whether or not they will return for another purchase or recommend the company to an associate.

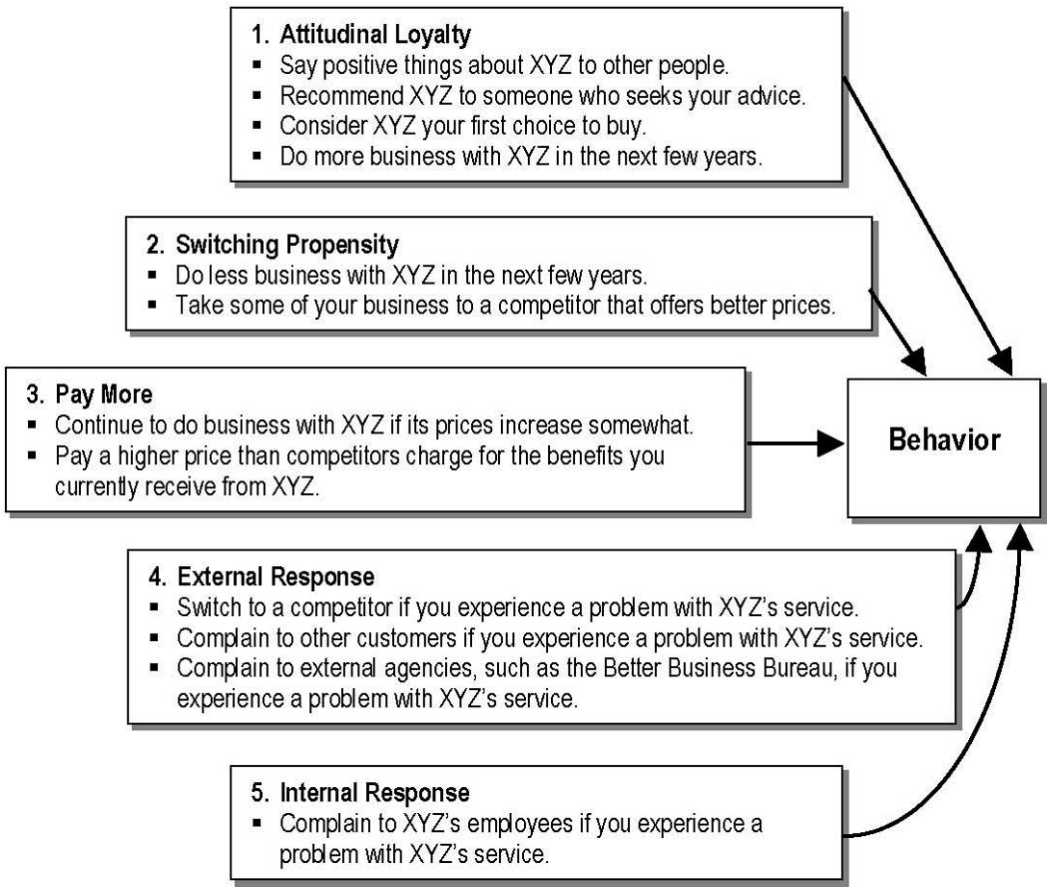

Figure 6- 4 Five Dimensions of Behavioral Intention[130]

.2 Survey Assistance from Research and Analysis Professionals

There are several organizations, such as the American Customer Satisfaction Index (ACSI), the Customer Satisfaction Measurement Association (CMSA), and Responsetek, who are structured to assist other companies with the following survey-related tasks:

[130] Derek Allen, *Customer Satisfaction Research Management,* ASQ Quality Press, Milwaukee, WI, 2004, p. 5. Copyright 2004 by ASQ Quality Press. Reproduced with permission of author.

- Setting objectives for the measurement process
- Measuring customer satisfaction levels by identifying reasons for satisfaction or dissatisfaction, creating quantification, calculating and ranking relative importance of satisfaction attributes, sharing knowledge of commonly used survey techniques, or other measurement method. For information of US-based customer satisfaction information, see The American Customer Satisfaction Index. For information on customer satisfaction in other countries, refer to the country report filed by various US State Agencies (e.g., USDA GAIN report) or those published by research organizations such as LIMRA
- Reviewing customer retention and determining why customers are staying or leaving
- Developing systems to track customer satisfaction by using database information to segment populations, create statistical analysis, report on improvements made in customer service activities, etc.
- Converting previous customer service tracking systems into other models and approaches
- Exploring how company customer satisfaction compares to competitors' customers
- Facilitating link between customer satisfaction and internal performance improvement processes to drive change

6.2.2 Analyzing Current Levels of Customer Satisfaction and Recommending Strategies for Improvement

In order to effectively measure and address customer satisfaction, managers must be able to:

- Select a meaningful customer sample population
- Design questionnaires
- Administer the survey or interview process
- Analyze data
- Develop action plans based on survey or interview results

.1 Working With What Is Important to Customers

Determining which attributes of a product or service are important to a customer is challenging. There are two options for doing so:

- **Stated importance,** determined by asking customers how important the item is
- **Derived importance,** determined by calculating the relationship between attributes and satisfaction[131]

Once companies know which elements of satisfaction matter most to their "high value" customers, they can begin to identify and work with "breakpoints." Most customers have a vision of what they consider acceptable service parameters (how long they will wait in line

[131]"Measuring What is Important to Customers." Available at http://www.busreslab.com/tips/tip3.htm. Viewed 08/10/09.

for service, etc.). Breakpoints are the high and low limits (number of minutes, etc.) that will cause customers to change their purchasing decisions.

Putting It Into Practice: How can you help determine what is important to customers? How do you use that knowledge every day?

.2 Improving Survey Techniques

Because customers and products continually change, the customer surveying process is necessarily dynamic and on-going. Despite the dynamism, however, managers should be cautious about modifying the customer satisfaction survey tools.

Advantages of changing questionnaire content:

- Keeping up with changing customer expectations
- Adding an assessment element that was overlooked in the previous survey
- Soliciting responses about new products and services
- Streamlining process (make shorter for customer so that they are more likely to participate, etc.)
- Gaining feedback on company initiatives (implementation of a customer service training program for staff, etc.)

Disadvantages of changing questionnaire content:

- Complicates tracking process and statistical analysis
- Data becomes difficult to trend (but not impossible)

Recommendation: For tracking purposes, keep the measurement questions for customer satisfaction unchanged.

.3 Company Improvement Strategies

In order to ensure that customer satisfaction data is used to improve company practices:

- Elicit top management commitment
- Link customer satisfaction scores with staff monetary incentives
- Recognize employees who contribute to customer satisfaction
- Identify, measure, and track operational variables which drive satisfaction scores
- Develop customer-based improvement goals
- Implement plans for improving operational variables
- Incorporate customer satisfaction skills into employee training programs

- Measure and plan for improvements in employee satisfaction
- Implement changes in corporate hiring practices[132]

6.3 Marketing and Branding Techniques

Marketing drives the sales process. Strategic marketing efforts assist organization attempts to determine what customers need and want and further guide development of the strategy for bringing the product to the marketplace. Marketing activities begin when the product is moving from R&D to production.

Organizations vary in their marketing focus:

- **Customer:** What does the customer need and want?
- **Competitor:** What are our competitors offering, and how can we distinguish ourselves in the marketplace?
- **Inter-functional coordination:** What would be the most efficient and effective ways for the company to maximize its resources?
- **Profit orientation:** What will bring the greatest revenues to the company?[133]

6.3.1 Knowledge of Marketing Techniques

.1 The Four Ps of Marketing

Marketing involves a mix of activities commonly discussed in terms of the Four Ps of Marketing (see Figure 6-5).

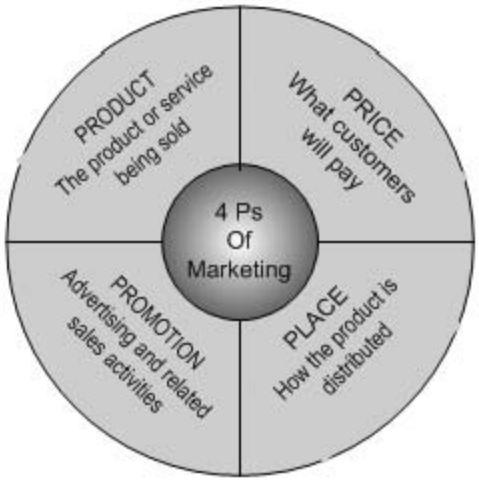

Figure 6- 5 The Four P's of Marketing

[132] "Improving Customer Satisfaction Once a Customer Satisfaction Measurement Program is in Place." Available at www.busreslab.com/tips/tip11.htm. Viewed 08/10/09.
[133] C. M. Chang, *Engineering Management: Challenges in the New Millennium,* Pearson Prentice Hall, Upper Saddle River, NJ, 2005, p. 255.

.2 Marketing Approaches

There are innumerable marketing theories and approaches. On the one side of the spectrum are simple approaches to marketing. They are primarily aimed at generating attention and can be characterized as:

- Simple
- Targeted
- Flexible
- Energetic
- Low cost
- Use networks

On the other end of the spectrum are more sophisticated approaches like "precision marketing" (see Figure 6-6).

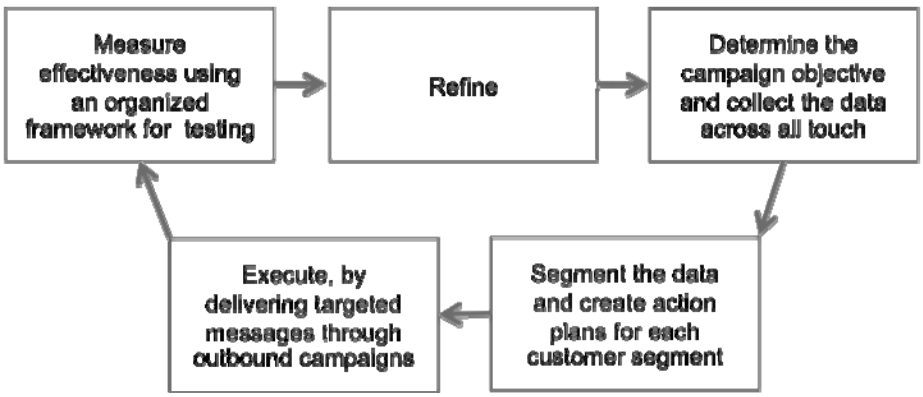

Figure 6- 6 The Precision Marketing Cycle[134]

Putting It Into Practice: What kinds of input from engineers does precision marketing need?

.3 Marketing Communications

Market efforts employ a range of communication vehicles, including:

- **Public relations:** "Free" media coverage obtained by distributing press releases and developing relationships with media professionals to enhance company or product image
- **Advertising:** Reaches a larger number of prospective buyers in a shorter period of time, but may have the least impact on immediate purchases

[134] Jeff Zabin and Gresh Brebach, *Precision Marketing: The New Rules for Attracting, Retaining, and Leveraging Profitable Customers,* John Wiley & Sons, Hoboken, NJ, 2004.

- **Direct mail/marketing:** Uses a database of potential customers to solicit purchases
- **Trade shows/exhibitions:** Theme-based events where industry professionals can explore available product options
- **Sales promotions: S**hort-term strategies designed to boost sales
- **Web-based:** Uses various Internet venues to distribute messages (websites, e-mail, etc.)
- **Personal selling:** Face-to-face communication — especially useful when explanation of product/service is required
- **Packaging:** Uses various aspects of product package to communicate key messages
- **Point-of-sale:** Messages delivered through various media at the location where products are bought

6.3.2 Applying the Techniques, Interpreting the Results, and Making Appropriate Recommendations

.1 Marketing Planning

Marketing planning is a complex process, involving five key stages, as shown below:

Stage 1 – Research –Assess the environment

Stage 2 – Strategic — Develop strategies and goals

Stage 3 – Tactical — Choose approaches, tools, etc., to be used

Stage 4 – Implementation — Begin marketing activities according to plan

Stage 5 – Evaluation — Assess effectiveness of plan and activities (the extent to which goals were met)

The elements of each of these stages are listed in Figure 6-7 below.

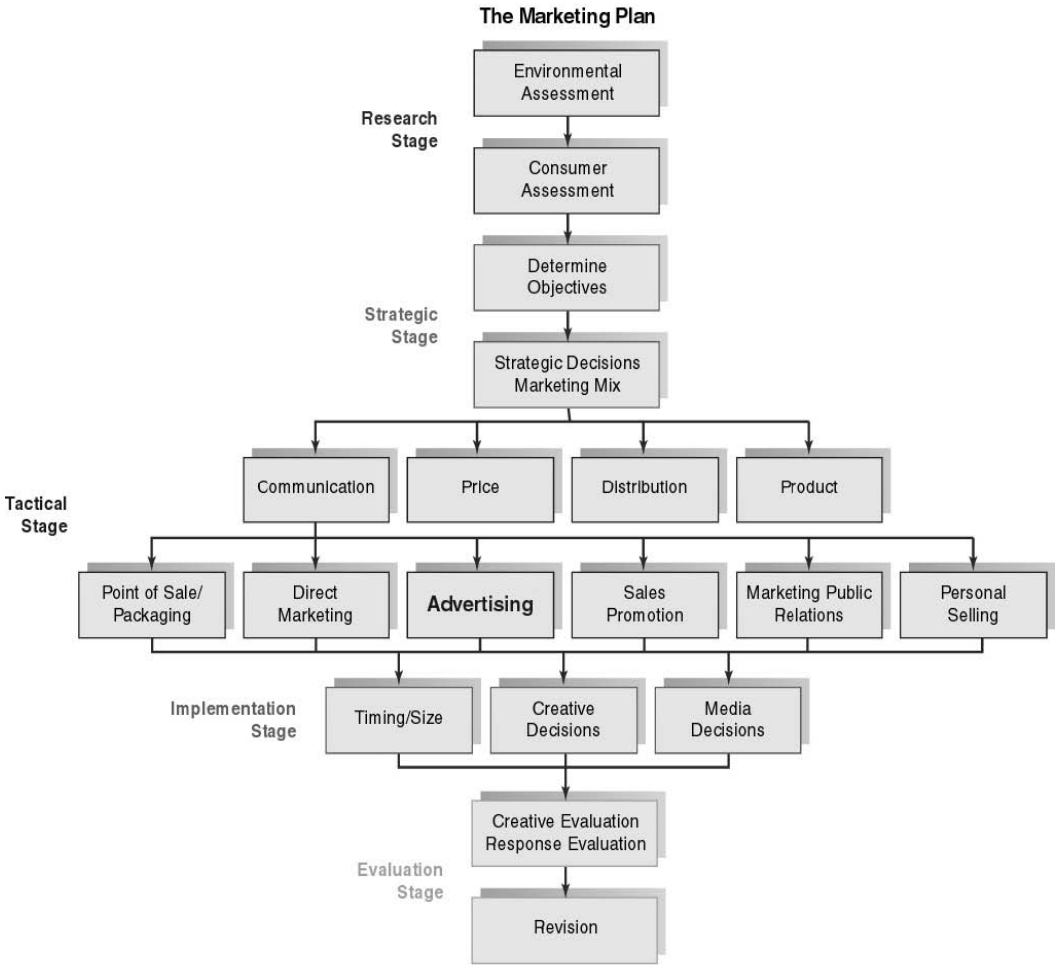

Figure 6- 7 Marketing Plan Elements[135]

Putting It Into Practice: To what extent have you been involved in marketing activities? How can you develop you skills by involving yourself to a greater extent? What knowledge and skills will you need to develop?

.2 Market Segmentation

Some companies use what is termed an undifferentiated marketing approach with a goal to develop a single marketing approach that will appeal to as many potential customers as possible. Alternatively, if the market base is too diverse, marketers segment the market by dividing the potential customer base into groups based on a wide range of possible characteristics.

[135] "Advertising and the Marketing Process." Available at www.westga.edu/~mktreal.ADVCP3.ppt. Viewed 08/10/09. *Used with permission of Ms. Mary-Kay Rickard, Richards College of Business, University of West Georgia.*

Why segment the market?

- Match products and services to appropriate customer groups
- Create suitable channels to reach the customer groups
- Uncover new groups that may not have been sufficiently served
- Focus on niches that have been neglected by other companies

Market segments are comprised of a range of potential buyers who are not identical but have common characteristics and will predictably respond in a similar way to marketing actions. Some examples of typical *market segmentation* methods are outlined in Figure 6-8 below.

Sample Market Segmentation Methods	
Consumer Market	**Industrial Market**
Demographic	Standard industrial classification
Lifestyle	Size
Regional	Regional
National	National
Behavior	End-use segment
Neighborhood	Decision level

Figure 6- 8 Market Segmentation Methods[136]

While segmentation is useful, companies must be careful not to over segment. Over segmentation creates challenges for marketing efforts to reach or serve customers effectively.

.3 Evaluating Marketing Effectiveness

A simple model for determining the marketing effectiveness for a given product or service is to look at the extent to which the product and its marketing attract customers and encourage their retention (Figure 6-9):

[136] Fraidoon Mazda, *Engineering Management,* Addison Wesley, Harlow, England, 1997, p. 462.

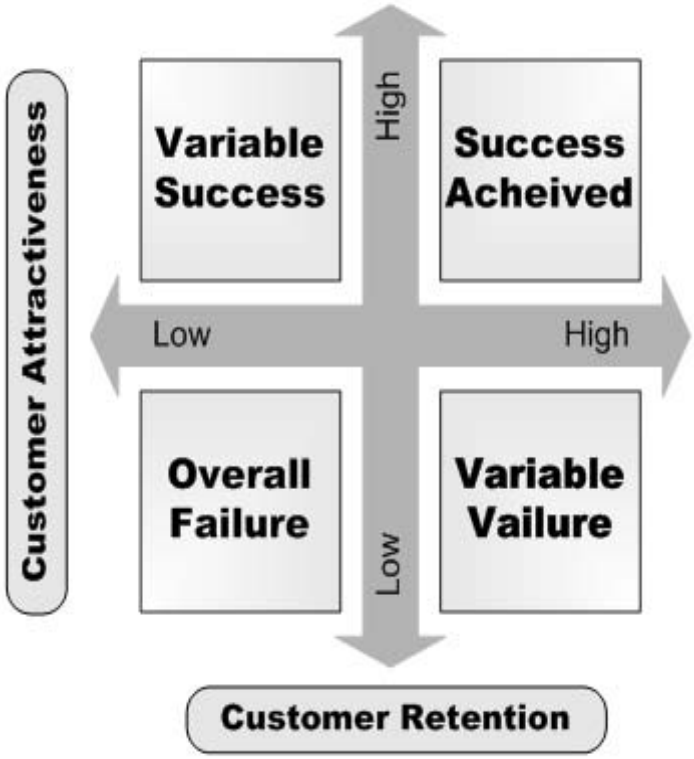

Figure 6- 9 Marketing Effectiveness[137]

A product marketing program is considered to be successful if:

- The product is attractive to the customer
- The company is able to satisfy customer needs and retain the customer's business

Failure to bring customers in by attracting attention or to retain customers significantly reduces the success of the marketing program.

There is no single formula for determining whether a marketing project has been successful or not. Each company will need to determine how it will quantify success for each product offered. When assessing the levels of product success, consider:

- **Sales forecasting:** Methods and data used to project revenues for a marketed product
- **Profitability:** Revenues earned after various costs associated with a project have been deducted
- **Performance statistics:** Data collection used as indicators of staff sales performance, including call statistics, values of orders taken, or billings made/sold
- **Segment growth:** The increase in market penetration as a result of product sales

[137] C. M. Chang, *Engineering Management: Challenges in the New Millennium,* Pearson Prentice Hall, Upper Saddle River, NJ, 2005, p. 256.

- **Product value to customers:** Perceived value of product to customers and how this perception might indicate future business opportunities
- **Portfolio development:** The extent to which the product enhances the *product portfolio,* and how the "brand" is perceived in the marketplace See the discussion of product portfolios in Section 6.4 below.

6.3.3 Communicating Recommendations to Non-Marketing Personnel

Sharing marketing recommendations successfully with staff involves the same approach and skills used for many business communications. Remember to:

- Determine specific objectives for the communication of your recommendations and state them up-front to focus receiver attention

  Are participants to take action? Solely or as a group? Are they to make recommendations for future actions to be taken, take information back to team members for further reflection and action, etc.?

- Match the message to the audience

  What are the receivers' knowledge and perspectives? How do they prefer to receive information? What concepts and terms are they familiar with? To what extent will they need background information?

- Use objectives to determine the methods of communication (informal update, formal written/oral report, face-to-face meeting, etc.)

  Will receivers need to discuss issues, or simply to listen to data presented? Will decisions need to be made by a group? Where are these individuals or teams located? What are the most effective meeting strategies?

- Assess communication format(s)

  What is the complexity or breadth of the information? Will receivers need handouts of visual representations to help them understand and retain information presented? Do receivers prefer extensive details or the abridged version?

- Select the most effective written "style" for your audience

  Do receivers like narrative or bullet-pointed text? What structural elements will they expect? What kind of introduction will be necessary? How are conclusions and recommendations best stated?

- When communicating orally, match receiver preferences

  Will they want a PowerPoint presentation to follow? What form of handout is best? To what extent is the communication a report, a facilitated discussion, a brainstorming session, etc.?

Putting It Into Practice: How do you prefer marketing information to be communicated? What can you inform the proper people of these preferences?

6.3.4 Developing and Promoting Brands

.1 What Is Branding?

Branding is the act of investing products with an "identity" that customers associate with various attributes such as quality, price, service, and image. The brand is considered to hold an implied promise that customers expect to be fulfilled; it creates value in the customer's minds. In essence, effective brands are company assets and must be conscientiously developed and monitored.

Four key characteristics of true brands:

- Name
- Known (by large portion of target audience)
- Symbol
- Trusted customer experience[138]

.2 Creating, Managing, and Marketing Brand Equity

Brands do not just "happen." They are strategically crafted. When developing brands:

- **Use research:** Solicit and use customer feedback to determine what customers truly value and how they will act on those values.
- **Use the company marketing plan:** *Use* the map for success you created.
- **Define the core brand's position clearly:** Ensure customers know what the product offers and where it stands in relationship to the competition.
- **Qualify your plan:** Clarify the target market and how the product meets their needs.
- **Define the value of your core product:** Direct how price, quality, and image determine customers' perceptions of the product.
- **Consider brand extension as adding value:** Keep up with market changes by adding companion products with differing features.
- **Have a reason for brand extension:** Use research to support extension activities.
- **Define primary and secondary goals:** Clarify and integrate marketing, sales, revenue and other goals.

[138] David Taylor, *The Brand Gym: A Practical Workout for Boosting Brand and Business,* John Wiley & Sons, Hoboken, NJ, 2003, p. 5.

- **Don't neglect public relations:** Seize all opportunities to enhance perception of the company and product(s).
- **Advertise:** Invest in making consistent, meaningful, and even humorous connections with the audience to build awareness and loyalty.
- **Recognize that promotions are tricky:** Strive to gain attention, but don't upstage the product. Keep the focus on the brand.
- **Remember the USP — unique selling proposition:** Avoid getting lost in the "glitz" and sacrificing focus on the customers' reason to buy.
- **Don't expand your line solely to look bigger:** Bigger is not always better. It can create confusion.
- **Be honest and ethical:** Rigorously protect the integrity of the brand.
- **Be careful with attack ads and comparison:** Take the high road. Negativity often backfires and benefits the competition.
- **Include a promise with your product:** Stress benefits and customers' reasons to buy. Consider adding something a little extra, like supporting noble causes.
- **If you can, be first. If you can't be first, be better:** Be imaginative, innovative, and original. Make the product stand out.
- **Listen:** Avoid arrogance and failure by being a company who actively listens to customers and staff.[139]

.3 Technology Branding

Branding in technology is often different from branding products that have shorter purchase lives. If you don't like the taste of the soda you bought today, you can buy a different one tomorrow. However, technological purchases are often significant investments in resources, and as such, buyers' perspectives are distinctly different. Potential technology buyers ask different questions:

- Will the product meet our specifications?
- Can we depend on the company that sells it?

"TechnoBranding" (compared to consumer branding) is more complex and less emotional and immediate:

- Products for business use
- Complex business products

[139] Joe Marconi, *The Brand Marketing Book: Creating, Managing and Extending the Value of Your Brand,* NTC Contemporary, Lincolnwood, IL, 2000, pp. 218-225.

- Need to distill and arrange features into a single idea (Microsoft — "making it easier")
- Ongoing, long-term relationship
- Training–dependent
- Considered purchase
- Study spec sheets, request capital, obtain purchase approvals
- Changes are often sudden and sweeping
- Buyer often has limits in purchase authority
- Multiple influencers
- Shorter *product life cycles*
- New versions or product makeovers are expected; the upgrade path counts
- Channels are fluid and changing
- Audience is looking for performance and competitive edge[140]

As a result, the branding of technology needs to be a technically-oriented, highly systematized and strategic process.

Putting It Into Practice: What are the differences between branding for technical and non-technical products? How do the differences affect what you do at work?

6.4 Product Portfolio Analysis

A product portfolio is the array of products a company offers to customers at any given time. It is important for most organizations to offer and manage a set of products at different stages in the product life cycle to maintain cash flow.

6.4.1 Analyzing a current product portfolio

.1 The Boston Matrix

In 1968, the Boston Consulting Group developed a tool for portfolio analysis, now commonly known as the *Boston Matrix*. A simple and effective tool, it assesses portfolio growth rate market share and can be used to assist with the management of organizational cash flow (see Figure 6-10).

[140] Chuck Pettis, *TechnoBrands: How to Create and Use Branding Identity to Market, Advertise & Sell Technology Products*, AMACOM Books, New York, NY, 1995, p. 44.

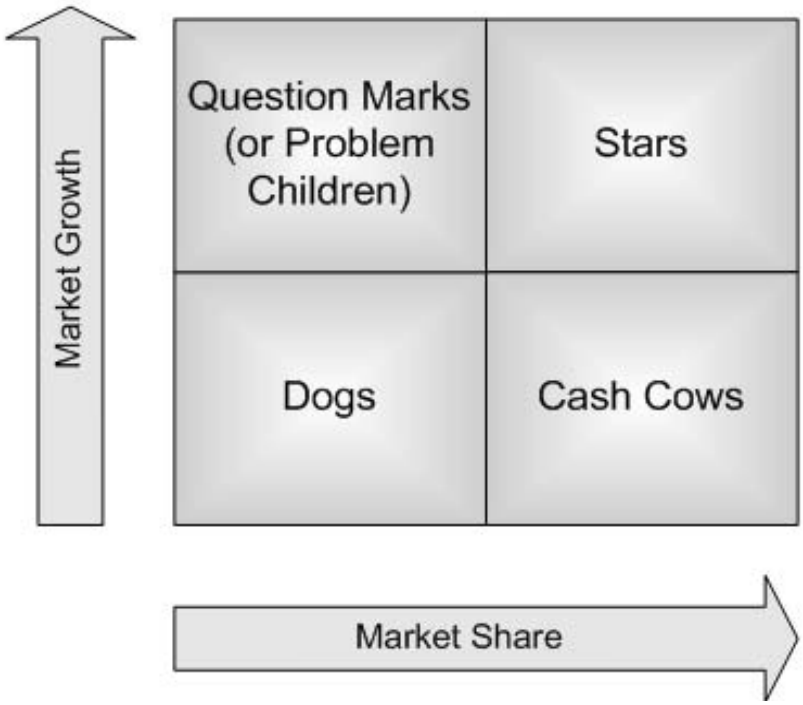

Figure 6- 10 The Boston Matrix

Normally, products are introduced as question marks. If successful, they become stars, which use resources and are still expanding their sales. The intent is that stars mature into cash cows who generate greater income with lesser investment of resources. As products further mature, they may begin to outlive their attractiveness in the marketplace and become dogs or question marks again (then known as problem children). Question marks/problem children need to be immediately addressed to avoid devolving into dogs. As dogs, products should be phased out. Companies cannot afford to keep products that are operational losses, even if some customers still want them.

Putting It Into Practice: Where on the Boston Matrix would you place your products? Does that indicate the need for a shift in strategy or a different course of action? What will you do?

.2 Evaluating Portfolio Strengths and Weaknesses

After determining whether each of the products in the company or team portfolio are stars, cash cows, question marks/problem children or dogs, "plot" each product on the Boston Matrix. Use larger symbols to represent products that represent a larger portion of your business (market share, revenues, etc.) and smaller symbols to represent more "minor" products. (See example in Figure 6-11.) The goal is to have a reasonably balanced portfolio with products at different categories in the matrix (Figure 6-11). It is normal to have some stars, a few cash cows, and a few dogs that are either products in trouble and in need of retooling or at the end of their natural life cycle.

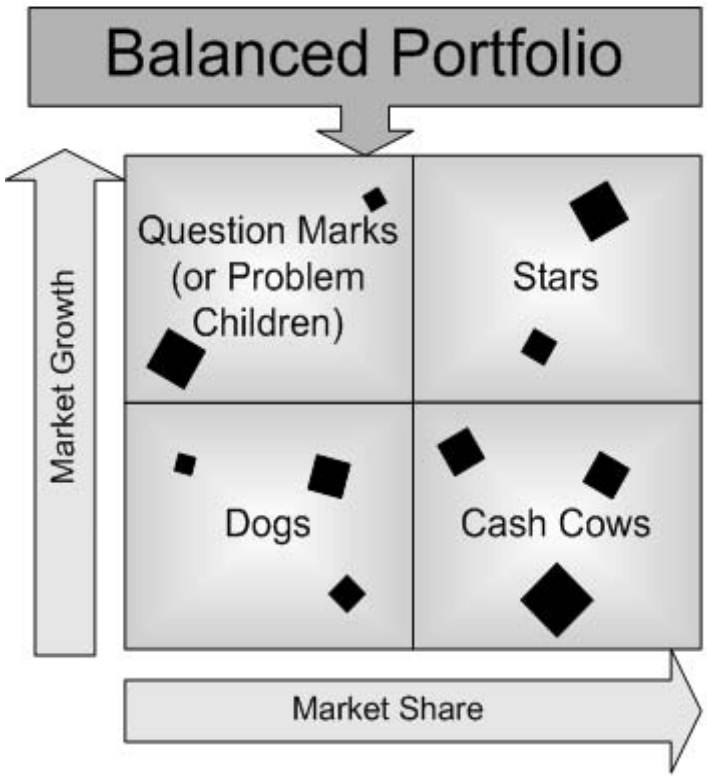

Figure 6- 11 Balanced Product Portfolio

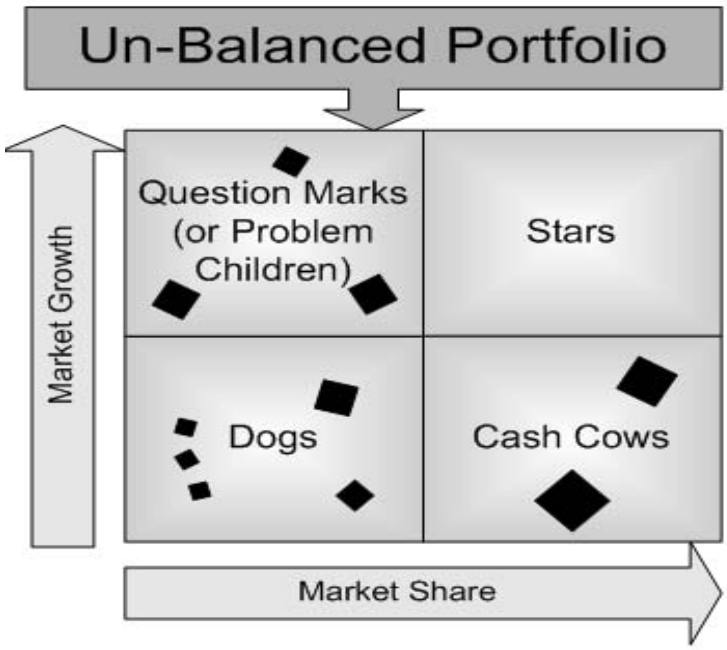

Figure 6- 12 Un-balanced Product Portfolio

.3 Difficulties With Product Portfolios

Unbalanced portfolios are indicators of an immediate need for strategic reassessment of current business practices. These portfolios can result from:

- Over investing in low-growth segments
- Under investing in high-growth segments
- Misjudging segment growth
- Not achieving market share
- Losing cost effectiveness
- Not uncovering emerging high-growth segments
- Unbalanced business mix

6.4.2 Evaluating the Appropriateness of the Portfolio Based Upon Competition, Technology and Market Forces, and Making Recommendations

.1 Product Life Cycle

Every product naturally progresses through what is termed its product life cycle (Figure 6-13).

1. **Introduction —** Includes the development and early stages of product's appearance in the marketplace. A time of higher costs and lower sales.

2. **Growth —** The period where product achieves increasing sales momentum. Customer awareness and revenues increase.

3. **Maturity —** Sales reaches peak and ceases to grow. Competition is on the rise. Cost of supporting the product declines and the ratio of revenue to cost is high.

4. **Saturation —** Early stage of sales decline due to increased competition entering the marketplace, need for the product is decreased, etc.

5. **Decline —** A decided drop in sales and profitability because of changes in fashion, technology, etc., or product simply outlives its usefulness. This leads companies to eventually cease production.

Figure 6- 13 The Product Life Cycle

Monitoring product life cycles enables managers to make choices about introducing new products, managing cash flow, determining resource allocation for marketing, etc. Having numerous projects in the pipeline at various stages of their life cycles is important for organizational cash flow and stability. (Figure 6-14).

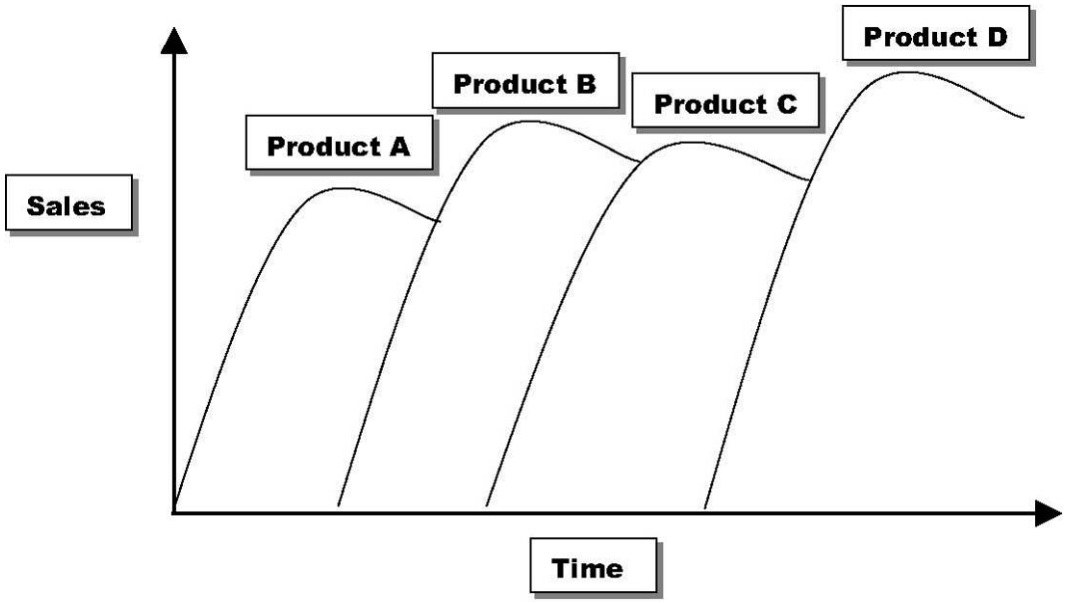

Figure 6- 14 Importance of Producing Successive Products

.2 Responding to Changes in Portfolio Makeup and Status

Addressing and assessing where products are in their life cycle combined with The Boston Matrix enables companies to respond to demands based on competition, technology, and market forces (see Figure 6-15).

Life Cycle Stage	Key Manager Tasks
Introduction (question marks)	• Target advertising and promotion campaigns at specific audience • Monitor initial sales closely • Maximize publicity.
Growth (stars)	• Carefully assess costs (fixed/variable); focus on making profits • Monitor the market place, especially competitors' reactions
Maturity (cash cows)	• Strive to maintain high market share • Monitor market looking for necessary changes/amendments/new strategies to be implemented
Saturation (questions marks/problem children)	• Develop new strategies and expand, exploit, or search out new markets • Develop new uses, focus on adapting the product, and develop its range • Improve the standard or quality
Decline and Withdrawal (dogs and problem children)	• Look to significantly reduce cost of supporting the product • Decide to support product or withdraw. (This may be dependent on availability of new products and whether fashions/trends will come around again.)

Figure 6- 15 Key Manager Tasks During the Five Stages of a Product Life Cycle[141]

Putting It Into Practice: How can you help to enhance the life cycle of your products?

6.5 Global Trade and International Operations

Regardless of their size, all businesses:

- Are challenged at home by overseas businesses
- Must consider sourcing materials overseas
- Must consider offshore production
- Must consider entering attractive markets overseas[142]

6.5.1 Knowledge of Global Trade and International Operations

Recent years have seen dramatic changes in international business. International trade agreements such as NAFTA (North American Free Trade Agreement) and GATT (General

[141] Product Portfolio Analysis. Available at http://www.bized.co.uk/educators/16-19/business/marketing/lesson/portfolio.htm. Viewed 08/10/09.

[142] Shay, J. "Operating in an International Business Environment" PowerPoint presentation for an MBA Essentials Course at the University of Montana, slide 11. Available at http://jobfunctions.bnet.com/thankyou.aspx?&cid=147&docid=85568&view=85568. Viewed 08/10/09.

Agreement on Tariffs and Trade) are removing barriers and facilitating a revolution in many companies. In order to engage in international operations, a business must at a minimum develop a marketing plan and entry strategy that might involve exporting, a joint venture, an export management company (EMC), licensing agreements, etc.

.1 Risks/Challenges of Global Operations

Entering the international marketplace is fraught with challenges for businesses. Business complexity increases dramatically due to:

- Cultural and language barriers
- Economic and political risks
- Religious beliefs
- Foreign exchange rates
- Societal norms
- Intellectual property protection
- Business/management practices
- Local trade practices
- Negotiation styles

.2 Various International Business Operation "Models" (Figure 6-16)

Indirect Exporting and Importing	Intermediaries are used for international business, and companies have no direct contact with foreign customers or companies • Advantage: reduced need for investing resources in gaining knowledge about the foreign company • Disadvantage: without an actual presence in the country, further business development is hampered
Direct Exporting and Importing	Companies work directly with foreign companies and customers • Advantage: company gains international experience and relationships • Disadvantage: company has greater costs and risks
Export Management Companies (EMCs)	EMC acts as agents for the contracting company and facilitate a variety of operations (sales strategy development, relationship development, etc.)
Trading Companies	Act as intermediaries and may be involved in several areas of the business (banking, manufacturing, etc.)
Direct Foreign Investments	Companies invest in full or partial ownership of foreign companies.
Licensing	Foreign company is given rights to use intellectual property and pays royalties.
Franchising	A foreign company purchases the rights to run an independent company as long as it meets the "parent" company standards.
Management Contracts	Domestic company contracts to manage the interests of an overseas company.

Figure 6- 16 International Business Operation Models[143]

[143] ibid., slide 30.

.3 International Operations Flowchart

Strategic analysis and planning for international operations follows similar patterns to domestic operations. Specifically, international operations consider (Figure 6-17):

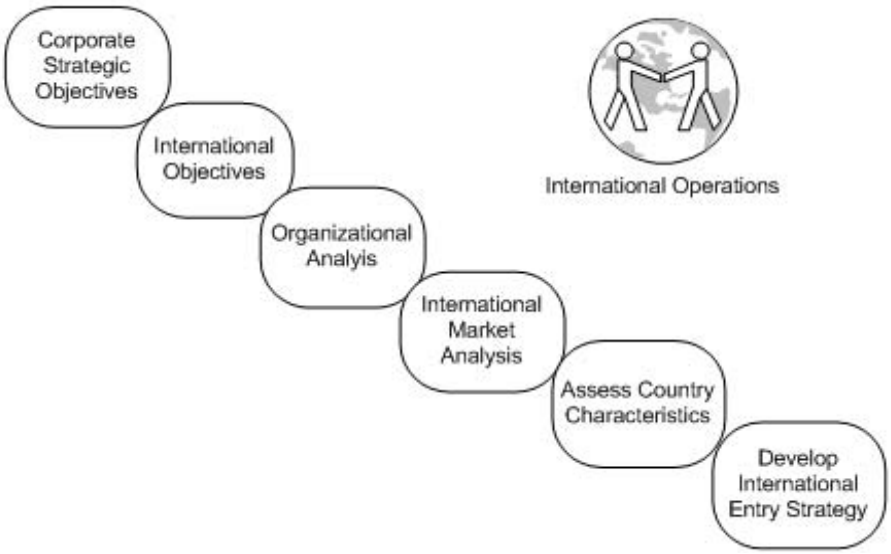

Figure 6- 17 International Operations

6.5.2 Knowledge of Cross-Cultural Management Differences

There are many reasons why organizations and managers are becoming increasingly sensitive to the need to maximize multiculturalism in their workplaces, including:

- Globalization of business practices
- Diverse points of view contributing to organization quality
- Labor force changes (increases in immigration, use of foreign-based workers, etc.)

.1 Challenges With Variations in Management Philosophies and Practices

Even when businesses have limited international activities, they are keenly aware of the impact of diversity and multiculturalism on day-to-day activities. Every organization has a culture — stated or unstated. Organizational culture is essentially the set of values, beliefs, customs, attitudes, and behaviors that members of an organization use to understand what the organization considers important and how it does things. Organizations wrestling with multiculturalism are addressing the issues that stem from the differences in values, beliefs, behaviors, customs, and attitudes held by people from different cultural backgrounds working within the same organization.

The definition of effective leadership varies from culture to culture, from organization to organization, and from country to country. Similarly, the frameworks used to understand those variations are numerous.

.2 Value Continuums

One model developed at the Washington International Center invites U.S. managers to view their own values and those of their cross-cultural counterparts as existing somewhere on a series of continuums.

For example, to what extent does a person value having control over time as compared to valuing human interactions (see Figure 6-18). Some individuals clearly will choose to risk being rude and cut a conversation short in order to maintain an appointment schedule. Others will opt to close a conversation more carefully and risk being a few minutes late to a future appointment. Neither option is inherently right or wrong, but will be chosen based on the values of the individuals, which they likely developed as being part of a cultural group.

The continuum model is especially useful, because it minimizes polarization and oversimplification of differences. People do not value “time” over “interactions” — they make a range of choices. The goal is to promote better understand of the range of values that surface in business interactions.

Classically "American" Values (as seen through the eyes of other culture groups)		Alternate Cultural Values
Task/Time and its Control (Punctuality, Keeping Schedules)	↔	**Human Interaction** (Relationships most important)
Personal Control (Each person controls her/his own life)	↔	**Fate/Destiny** (Events are controlled by a higher force)
Self-Help (Success and position are earned)	↔	**Birthright/Inheritance** (Success and position are ascribed through birth etc.)
Change (Connotes growth and progress)	↔	**Tradition** (Focus on heritage and precedent)
Future Orientation (Planning and goal setting for a brighter future)	↔	**Past Orientation** (Past and history are kept alive)
Individualism/Privacy	↔	**Group Welfare**
Competition	↔	**Cooperation**
Equality (Equal rights and opportunities for all)	↔	**Hierarchy** (Rank and status determine position)
Informality	↔	**Formality**
Practicality/Efficiency (The ends justify the means)	↔	**Idealism** (Doing things the right way)
Directness	↔	**Indirectness/"Face"**
Action/Doing (Results focused)	↔	**Being** (Process, inner oriented)
Materialism (External success)	↔	**Spiritualism** (Internal fulfillment)

Figure 6- 18 Cultural Differences[144]

Putting It Into Practice: Where would you place yourself on each of these continuums? What modifications in your behavior would be required to work more effectively with cross-cultural teams?

Much discussion centers on the realistic differences in leadership practices. However, it must be stated that researchers also find that there are several commonalities as well. The differences and commonalities are explored in the sections that follow.

.3 Key Management Competencies That Multinational Groups Agree On

There are several key management competencies on which multinational groups agree, including:

[144] L. Robert Kohls, "The Values Americans Live by." Paper prepared for the Washington International Center, 1984. Available at http://math.claremontmckenna.edu/ALee/extra/American_values.html. Viewed 08/10/09.

- Results-driven
- Fosters teamwork
- Analyzes issues effectively
- Manages the execution of activities effectively
- Committed to work
- Influence others
- Sound judgement[145]

While the management methods may require regional variations in style, the goals and desired results are strikingly similar.

6.5.3 Interacting with Managers in Other Cultures

Even within culture groups communication is an intricate process involving multiple layers of meaning and fraught with innumerable possibilities for misunderstanding. International interactions require special care and skill.

.1 Cross-Cultural Communication Breakdowns

Common causes of breakdowns in communications include:

Communication complexities: Words, idioms, tone of voice, emphasis, speed, emotion, body language, and the interpretation of these, are used to communicate multidimensional messages with complex meanings.

Translation difficulties: Even highly skilled translators can find cross-cultural translations challenging (i.e., no direct correspondence between words, multiple levels of meaning are difficult to convey and may be lost, and literal translations can be misleading).

Prejudice and stereotypes: Can unconsciously color listeners reactions negatively.

Communicator burn-out: When parties involved in difficult communications suffer from exhaustion, frustration, and anxiety, miscommunications become more likely.

.2 Facilitating Effective Cross-Cultural Interactions

Experts agree that in order to be truly effective managers must:

- Commit themselves to make adjustments to their communication style and move out of their own comfort zones

[145] C. Robie, "The Right Stuff: Understanding Cultural Differences in Leadership Performance" Paper prepared for Emerald Publishing Group, 2003. Available at http://jobfunctions.bnet.com/whitepaper.aspx?&cid=147&docid=133417. Viewed 08/10/09.

- Invest the time to learn to communicate differently and form new habits
- Develop open-mindedness and the ability to empathize with alternative perspectives
- Develop an authentic appreciation for differences in cultural attitudes and practices, not merely a tolerance for variety
- Practice taking on alternative perspectives — respecting alternative views as equal to their own
- Focus on the benefits of multiculturalism — help associates develop the same perspectives, skills, and behaviors
- Reduce barriers to communication and workplace interaction
- Communicate openly and sensitively about issues that arise because of cultural differences
- Support company efforts to promote diversity (mission statements, policies, etc.)

.3 Doing the Homework

Awareness of accepted business practices is critical to successful international sales and marketing efforts. Because cultures vary widely, there is no single code by which to conduct business. Most international interactions face failures primarily because managers have a lack of cross-cultural information. Numerous websites, training organizations, books, etc., offer cultural information. Go beyond the traditional cultural resources. Talk to business colleagues who have experience with the culture you are engaging. Foreign government consulates also offer a wealth of information on business customs and norms for their countries. Become a keen and sensitive observer.

Managers and organizations must make a commitment to learn as much about the culture as possible, including:

- Holidays — religious and national
- Standard business practices (e.g., customs for exchange of business cards)
- Business hours
- Religious practices
- Meal times and practices Historical highlights
- Currency
- Meanings of colors, numbers, symbols
- Cultural institutions Gift-giving customs
- Clothing
- Rules of etiquette (e.g., using titles, first names)
- Taboos

Although more difficult to define/describe, managers and organizations should also commit to learn about these aspects of cultural differences:

- Beliefs
- Oral communication practices (greetings, acknowledgments, small talk, responses to offers for refreshments, etc.
- Values
- Attitudes
- Perceptions
- Body language interpretations
- Written communication expectations (style, language, elements, etc.)
- Negotiation practices
- Political environment Perceptions of different types
- Welcome topics of conversation of humor

Successfully interacting with managers from other cultures is more than simply memorizing a set of "rules." The nuances of culture and communication can dramatically influence business success or failure.

Putting It Into Practice: What are your favorite sources of information for improving international business relationships? How can you develop your cross-cultural skills on a daily basis?

6.6 Pricing Strategies

Some would argue that pricing is an art form, because it requires juggling the need to price low enough so that customers will buy with the need to cover costs and maximize profitability. Careful pricing is vital to product success. Pricing too high will discourage buyers; pricing too low could endanger profitability.

6.6.1 Knowledge of Current Pricing Strategy

.1 Pricing Strategy Matrix

Pricing determinations can be made based on a number of variables. Frequently companies choose to position their prices based on perception of the product's quality. A low-quality, low-price item is considered to be economy priced. A high-quality, high-price item is considered premium.

Figure 6- 19 Pricing Strategies Matrix[146]

Premium pricing: Companies charge a higher price when the product or service is more "unique" or has a substantial competitive advantage. This is commonly done with luxury items.

Penetration pricing: Organizations choose to set artificially low prices for products and services in order to gain market share. This is a short-term strategy — once product has gained the desired market share, pricing is increased.

Economy pricing: The classic "no frills" price. In order to make this option viable for companies, they minimize expenses by keeping marketing and manufacturing costs as low as possible. Store brands are good examples.

Price skimming: Named because of the intention to "skim the cream off the top," this strategy leads companies to charge higher prices, because the product has a significant competitive advantage. It is assumed that initial buyers will be more price insensitive, but this price is not sustainable and will need to be reduced. Example: books being introduced in hardback and then moved to soft-cover versions.

[146] "Pricing Strategies." Available at http://www.marketingteacher.com/Lessons/lesson_pricing.htm. Viewed 08/10/09.

.2 Common Product Pricing Methods

Figure 6-20 below illustrates several common product pricing methods. A more detailed explanation follows.

Figure 6- 20 Common Product Pricing Methods

Cost-driven: Price is set by calculating production costs and adding a profit margin to it. Price = Cost + Markup (usually a percentage of cost)

Profit-driven (target return): Similar to cost driven, this is used when companies prefer to plan in terms of fixed amounts of profit. Price = Cost + Profits (a targeted ROI, etc.)

Market-driven: Focusing on what customers are willing to pay, this option often results in competitive bidding processes

Competitor-driven: Competitor product and pricing are surveyed to effectively "shut out" competition or match competitor pricing — essentially maintaining the status quo

Demand-driven: With high product demand, sellers charge more; low demand results in dramatic price drops in order to move the product from inventory

Needs-based: Considers how critical the product is for the potential buyer

Value-based: Stresses to the customer the improvement in quality, profitability, etc., that the seller expects the customer to seize — especially in relationship to competitors' product(s). This can be the most profitable.

6.6.2 Evaluating the Appropriateness of the Pricing to the Competition, Technology, and Market Forces

Assessing the extent to which pricing strategies and methods used are the most effective, a number of issues need to be considered. Organizational priorities, for example, determine whether revenues and profits, overall image of the organization, capturing market share, or even enabling the company to survive during a difficult period are preeminent.

.1 Determining and Re-evaluating Price

Develop the marketing strategy: Conduct market analysis activities and determine how product will be positioned

Make marketing mix decisions: Describe the product and how it will be distributed and promoted

Estimate the demand curve: Explore the relationship between expected demand and its impact on price

Calculate cost: Look at fixed and variable costs related to the product

Understand environmental factors: Pay attention to competitor position and pricing, as well as legal constraints such as price-fixing, discrimination, and dumping

Set pricing objectives: Determine whether goal is to maximize profits, revenues, quantity or profit margin; recover costs; maintain the status quo; help the company survive; etc.

Determine pricing: structure a cost that achieves the goal set above[147]

.2 Factors Companies Consider When Determining Price

Depending on the scope of the organization, internal staff may have significant expertise in pricing practices. There are numerous independent consultants who can assist with this effort and a wide array of software solutions that enable managers to examine several different pricing scenarios. Data used to determine pricing will be representative of:

- **Product characteristics:** Companies look at the value that products have for customers. This may be due to dominance in a market niche, key benefits, relative uniqueness, low maintenance costs, etc.

- **Marketplace characteristics:** Concerns for competition dominate. Greater competition leads to lower prices. If competition also faces barriers to entry into the marketplace due to resources or length of time needed to get competitive products to the market, then prices will be higher.

- **Distribution and production capabilities:** With effective production and distribution channels in place, companies will strive to grab an early market share. As production volumes increase, production costs usually decrease and lead to a pricing reduction as well.

- **Price-quality relationship:** While customers are looking for a good value, research shows that customers generally believe that products that are priced too low will also be of a lower quality and will therefore not buy them. Balancing the perceptions of quality, price, and value effectively increases sales.

- **Financial aspects:** The stronger a company's financial position, the more flexibility it may have with pricing. Stability enables managers to choose between shorter- and longer-term pricing and profit strategies.

[147] "Pricing Strategy." Available at http://www.netMBA.com/marketing/pricing. Viewed 08/10/09.

- **Relative position of power:** Supply and demand issues will give relative power advantages to buyers or sellers. The stronger the competition, the weaker the position of the selling company. This can lead to utilization of a variety of negotiating and auctioning processes.[148]

6.6.3 Communicating the Impact of Pricing on Marketing Strategy

Bringing together and communicating the results of pricing strategy assessment and analysis is much easier with tools designed specifically for the purpose. Whether using automated features or developing them in-house, remember to:

- Use graphic representations (graphs, charts, etc.)
- Find vehicles to make critical data comparisons easy to understand
- Distill the report. Remember that sometimes more is just more, not better
- Introduce readers to the objectives
- Offer simple, direct narrative that describes the "take-aways"
- Directly connect marketing strategy change recommendations to data — the why
- Summarize recommendations at end of report — include action steps

As always, consider the audience. If, for example, pricing issues are complex and directly related to highly technical issues, and marketing staff has limited technical expertise, then communication will need to be modified accordingly. Reports may need more contextual information, descriptions of terms and process, or summaries of statistical analysis.

Written reports are often sufficient for sharing information. If receivers will need to ask questions, explore related issues, or determine actions to be taken as a group, then a meeting format will be best. When analysis information is extensive, be sure to give participants ample time to review materials before the meeting.

Putting It Into Practice: What impact do you have on pricing decisions? Do you believe that you should have more or less involvement? Why?

[148] C. M. Chang, *Engineering Management: Challenges in the New Millennium,* Pearson Prentice Hall, Upper Saddle River, NJ, 2005, pp. 272-275.

Review

After completing *Domain 6: Marketing, Sales and Communication Management,* you will be able to answer the following questions.

1. Describe how an advertising campaign is created.

2. What skills do managers engaging in international marketing efforts need to develop?

3. What are the primary tools used for collecting customer satisfaction data? What types of data are collected?

4. Describes the steps necessary to ensure that customer satisfaction research is actually used to improve product design and delivery.

5. List and describe at least five ways that companies can assess the success of marketing activities.

6. Explore some of the steps that companies take to develop branding. How might branding of technology differ from branding other products and services?

7. Describe the Boston Matrix and discuss how it is used in portfolio analysis.

8. Identify the five stages of the product life cycle. What issues should managers be addressing at each stage?

9. What are the challenges that managers face when embarking on international operations?

10. How might leadership and management practices differ from culture to culture? List at least eight things managers should do to facilitate better interactions within cross-cultural teams.

11. Discuss the role that engineers play in pricing. What factors are taken into consideration? What pricing models can be used?

For Further Information

- http://www.theacsi.org — American Customer Satisfaction Index (ACSI). "A uniform and independent measure of household consumption experience." ACSI tracks trends in customer satisfaction and provides benchmarking insights of the consumer economy for companies, industry trade associations, and government agencies.

- http://www.marketingpower.com — American Marketing Association (AMA) Journal of International Marketing. A good source for timely and relevant articles on international marketing.

- http://www.Globaledge.msu.edu — Global Edge. A knowledge web-portal created by the Center for International Business Education and Research at Michigan State University. It offers more than 5,000 online resources, country insights, news, research/teaching resources, and decision-support tools for managers.

- http://www.executiveplanet.com — Business culture guides/articles with cultural business tips for specific countries.

- http://www.trade.gov — The Web site of the International Trade Administration (ITA) of the Department of Commerce. Information and services regarding U.S. international trade policy.

- http://www.fita.org — The Federation of International Trade Associations (FITA) offers access to over 450 independent international associations.

Domain 7: Leadership and Organizational Management

Domain Champions: Nicholas J Gianaris, Ph.D.
Jerry Westbrook, Ph.D.

7.1 Schools of Management Thought

- 7.1.1 Management Function School
- 7.1.2 Behavioral School
- 7.1.3 Mathematical School

7.2 Managing and Motivating Knowledge Workers

- 7.2.1 The Impact of Assumptions
- 7.2.2 Identifying and Meeting Employee Needs
- 7.2.3 Motivator-Hygiene Concept
- 7.2.4 Achievement-Affiliated Orientations
- 7.2.5 Management Styles and Group Processes
- 7.2.6 Defined Management Systems
- 7.2.7 Managerial Grid Approach

7.3 Organization Structure

- 7.3.1 Organic vs. Mechanistic Structures
- 7.3.2 Typical Structure Types
- 7.3.3 Models of Structures

7.4 Management Systems and Systems Thinking

- 7.4.1 Systems Thinking
- 7.4.2 The Five Disciplines
- 7.4.3 Openness and Localness
- 7.4.4 Archetypes
- 7.4.5 Case Studies and Problem Solving
- 7.4.6 Identifying Management Systems Applicable to Tech-Driven Organizations

7.5 Leadership

- 7.5.1 Management vs. Leadership
- 7.5.2 The Covey Approach
- 7.5.3 The Kouzes and Posner Transformational Leadership Approach
- 7.5.4 Proactive Leadership
- 7.5.5 Leadership Succession Planning

7.6 Human Resources Management

- 7.6.1 Recruitment, selection, and compensation practices
- 7.6.2 Managing a diverse workforce
- 7.6.3 Labor Relations

Domain 7: Leadership and Organizational Management

Key Words and Concepts

Compensation	Items earned by the employee for the job that they do. Examples include salary, benefits packages, bonuses and rewards.
EEOC Regulations	The regulations set by the U.S. Equal Employment Opportunity Commission to assure fair employment practices are extended to all employees and potential employees regardless of diversity factors.
Hygienes	Term coined by Frederick Herzberg to describe certain workplace factors that, alone, are unlikely to increase worker satisfaction or productivity. These include company policy, working conditions, peers, supervisors and pay.
Knowledge Workers	Term coined by Peter Drucker to describe workers whose primary labor is intellectual, as opposed to manual. This term is particularly applicable to engineers, engineering managers and to many other workers in the Information Age.
Linking Pin	A middle management function responsible for coordinating, inspiring cooperation and managing conflict between upper management and direct reports.
Mechanistic Organization Structure	Organizational structure governed by rigid policies and job descriptions. Frequently used in mass production industries (e.g., automotive manufacture) where decisions are primarily made at the top of the organization.
Motivators	Term coined by Frederick Herzberg to describe certain workplace factors that motivate employees, including knowledge workers. Examples of motivators include: recognition, responsibility, the job itself and opportunity.
Organic Organization Structure	A flexible organizational structure with few set rules. This type of structure is well suited to meet the requirements of a rapidly changing technological environment.

Key Words and Concepts (cont)

Recruitment	The process of locating new team members whose knowledge, skills, and abilities fit the needs of the team.
Schools of Management Thought	Schema developed by Dr. Harold Koontz to identify six categories of management thought. Some of the schools see management as adherence to well-conceived rules; others see it as the application of economic and mathematical principles or the application of lessons learned from behavioral science.
Selection	The process of establishing selection criteria, interviewing and hiring the most qualified job applicant.
Strategy	In a systems context, strategy is one way of integrating organizational resources, including people, to meet the needs of forces or players external to the organization. These include customers, society and suppliers.
Systems Thinking	An approach to organizational thinking outlined by Peter Senge. This approach holds that organizations are composed of inter-linking systems and should be managed accordingly.
Workforce Diversity	Using inclusion as a means of achieving superior performance by recognizing the unique contributions of each employee towards meeting the company's goals.

Introduction: The Integrated Management Model

When engineers are promoted into management positions without first having had formal management training or much management experience, they likely lack a thorough understanding of key management principles. This is unfortunate, as such principles provide managers—both new and seasoned--with the guidance they need to navigate day-to-day management challenges, especially those involving the management of people.

Domain 7 examines a number of these management principles, focusing in particular on the management styles and organizational structures that are most conducive to managing professionals--including engineers--whose primary labor is intellectual. Dr. Jerry Westbrook's five-element Integrated Management Model (Figure 7-1) is used as the basis of this examination.

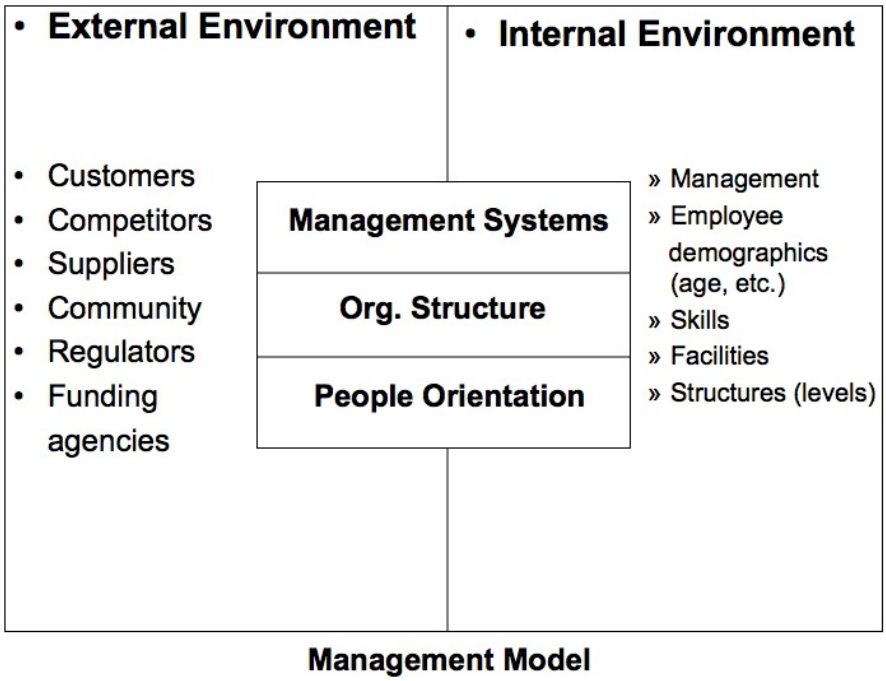

Figure 7- 1 Westbrook's Integrated Management Model[149]

The Integrated Management Model holds that management consists of three key elements: management systems, an organization's structure and management's orientation towards its people. When combined, these inter-related building blocks determine how the manager and the organization will interact with and be impacted by the model's other two elements: the internal and external business environments.[150]

Domain 7 is organized around each of the five elements of the integrated management model. After a brief, context-setting survey of the six key schools of management thought, each of the model's five elements is examined in depth. Each discussion focuses on the way that the

[149] See Westbrook, Jerry D., "An Integrated Theory of Motivation", Engineering Management International, vol.1, 1982, 193-200; Elsevier Publishing Company, Amsterdam

[150] ibid.

element—alone and in concert with the other elements--can be optimized to enhance the productivity of engineers and other knowledge workers.

The domain concludes with an examination of key human resources management concepts and practices. These include the recruitment, selection and compensation of employees, guidelines for the management of a diverse workforce, techniques for conflict resolution and tips for the management of labor relations.

.1 The External Environment

Each element of the external environment exists outside the organization but has direct impact upon it. Typical elements comprising the external environment are:

- Customers
- Competitors
- Suppliers
- The Community
- Regulators
- Funding Agencies

An effective manager must understand and be prepared to deal with each of these strategically. For example, a strong customer may become vertically integrated and become a competitor. A supplier may give competitors better prices. Competitors' research and development programs may yield a better, cheaper product. The community may support a local organization or may attempt to put unfavorable regulations in place. For all of these reasons and more, a manager must be sensitive to the external environment, and remain keenly aware of the threats and opportunities it provides.

.2 The Internal Environment

An organization's internal environment is the set of internal resources that enable its successful operation. Effective managers must determine if the available resources are adequate to the challenges faced by that organization.

An organization's internal environment includes the following:

- The skill base of its work force
- Key employee demographics
- Age and condition of its facilities
- Management style and organization culture

A strategic analysis of the internal environment yields its key strengths and weaknesses. The resources available to an organization also determine priorities for decision-making.

.3 Management Systems

Systems are the way processes are organized to gets things done. There are many types of systems: everything from accounting, purchasing and production to strategic efforts to coordinate workflow. It is the latter that is of most interest. Many powerful and useful

systems have been implemented in the past twenty years. Further back, one of the first management systems was management by objectives. Then Zero Defects, Total Quality Management and Business Process Re-engineering became popular. Each had a half-life of approximately two years and was gone. They were good systems that didn't last. Why? Many were never implemented very well. Middle management gave lip service to some but never really supported them. Upper management felt like the systems were for workers, not them. The structures of some organizations were too complex to support the system. The reasons were systemic. The whole organization failed to adopt and use the new system.

Lean Enterprise and Six Sigma are the management systems currently in use. How long these management systems survive depends largely on how effectively organizations implement them. The model suggests ways that good systems can be effectively implemented and maintained.

.4 Organization Structure

An organization's structure is the way an organization arranges its components to carry out its mission. Organizational structure is not well understood and as a result many organizations find themselves constantly "reorganizing." Organization Structure is therefore the silent force behind the organization's success or failure.

Structure can be defined in several ways.

- Complexity - The number of organizational levels that communication must travel between and among
- Control systems - The number of employees reporting to one manager, also referred to as "span of control"
- Culture - How members of the organization relate to each other – formally or informally, vertically or omni-directionally

The more sophisticated the organization's technologies, the faster the communication within the organization must be. Similarly, a sophisticated technological organization benefits from a relatively flat structure. Complex, tall structures do not suit rapidly changing business environments.

.5 People Orientation

Much of a knowledge-worker-based organization's success depends on how the organization relates to its employees. Most organizations proclaim that their employees are their most valued asset, but still make decisions that take them for granted (e.g., massive outsourcing to other countries). Acting in a manner that generates trust allows a knowledge-worker-based organization to succeed. Failure to do so is the reason so many of the systems mentioned above failed.

.6 The Integrated Management Model

Together, all of the elements discussed above form an integrated management model where each element works in relation to all the others. For example, systems fail when all of the elements do not act in a coordinated manner. The internal environment must have appropriate resources. Analysis of the internal environment yields an organization's strengths and weakness. The external environment must be mined for opportunities and

potential threats. Appropriate systems must be used and the structure must support those systems. Knowledge workers must work in a culture that challenge and appreciate their contributions.

The remainder of Domain 7 presents each element of the integrated management in detail:

- A context-setting survey of the key schools of management thought is delivered in **Section 7.1: Schools of Management Thought.**
- Concepts for managing and motivating knowledge workers both individually and as a team are presented in the **Section 7.2: People Orientation.**
- Approaches to assessing the effectiveness of an organization's structure is presented in **Section 7.3: Organization Structure.**
- Methods of integrating organizational systems are discussed in **Section 7.4: Systems Management**.
- A systems view of **Leadership** is the subject of **Section 7.5**.
- Making management systems function as designed is discussed in **Section 7.6**.

Summary

Students of engineering management are expected to understand that there are different approaches to management. Knowledge workers are typically at the heart of a technology-driven organization and their efforts are to be encouraged and appreciated. Engineering managers must deal with a changing external environment and be ready to develop the internal resources needed to meet that challenge.

There are a wide range of management styles, philosophies and practices. The purpose of this section is to review that range and demonstrate how various elements of each are of use to the modern day engineering manager. The review will also form a foundation for the Integrated Management Model that is the centerpiece of this domain.

7.1 Schools of Management Thought

7.1.1 The Management Process School

In their article "The Management Theory Jungle," Koontz and O'Donnell condense the range of contemporary management practices into six major "Schools of Management Thought."[151] They are:

- The Management Process School
- The Empirical School
- The Social Systems School
- The Human Behavior School

[151] Koontz, Harold, "The Management Theory Jungle," *Journal of the Academy of Management*, (December 1961).

- The Mathematical School
- The Decision Theory School

Because there is significant theoretical overlap amongst these schools—i.e., both the Management Process School and Empirical School deal with management principles; both the Social Systems School and the Human Behavior School deal with the behavioral aspects of management; and both the Mathematical School and Decision Theory School deal with mathematical approaches to management--the six schools may be further condensed into three: the Management Process School, the Behavioral School and the Mathematical School. Each of these three schools is discussed in detail below.

.1 The Management Process School

The Management Process School maintains that management is a process that can be defined, taught, learned, and applied. This School also holds that management consists of the following activities: planning, organizing, staffing, leading, communicating and controlling. By focusing on these activities, the individual manager improves both his or her management skills and the productivity of the overall organization. This is in opposition to the argument that management is an innate quality that one must be born with.

Typical management principles within the Management Process School include the following:

- **Chain of command**: Communication is primarily vertical, guided by direct reporting relationships.
- **Division of Labor:** Work is divided into relatively small tasks so that lower skilled workers can be trained to do these tasks repetitively. This concept was developed during the Industrial Revolution when employees were predominantly untrained and uneducated women and children. It is now being applied to a better trained and educated workforce with mixed results.
- **Narrow span of control:** This is the number of direct reports per manager. Span of control depends on many factors including the skill level of the workforce and the number of tasks that the manager supervises. Narrow spans of control add supervisors and overhead to the organization. Division of labor tends to reduce that ratio of supervisors to workers.
- **Unity of command:** One worker has one supervisor to minimize any confusion as whom to take orders from.

Research by Mintzberg indicates that the Management Process School's list of management activities does not adequately describe the management function.[152] It fails to include the important communication role that managers play within an organization (i.e., the manager as communication center, as a disseminator of information and a spokesperson for the organization, etc.). Managers also influence work, allocate resources and handle disturbances. Despite its limitations, however, the management process's list of functions does provide us with a useful conceptual framework for describing managerial activities.

[152] Mintzberg, Henry, "Managerial Work: Analysis From Observation," Management Science, Vol. 18, No. 2, October 1971.

.2 The Empirical School

The Empirical School, as promoted by the Harvard Business School, utilizes case studies of real world management scenarios to train and educate future managers and organizational leaders. Principles of management are based on actual business cases or the study of real situations. The case study approach allows students to learn from managers' successes and failures and to begin forming their own principles of management.

7.1.2 Behavioral School

.1 Social Systems School

This school of management thought examines how workers perform in groups or teams. The Hawthorne Experiments were the catalyst for this school's core concepts. They demonstrated that both external conditions (e.g., lighting, work rules, etc.) *and* a team's relationship to organizational goals, affect productivity. Many researchers have put forth management theories on the role of group processes in achieving organizational success, including Blake and Mouton (The Managerial Grid), Likert (The Four Systems), and Katzenbach and Smith (The Wisdom of Teams).[153]

.2 The Human Behavioral School

This school holds that management should recognize employees as organizational assets who *want* to get work done, as opposed to workers merely responding to supervisory dictates. This behavioral approach is especially important in the management of knowledge workers, as the way they feel about their job has a significant impact on their effectiveness. Individual theories within this school include Herzberg's "Motivators and Hygienes," Maslow's "Hierarchy of Human Needs," McGregor's "Theory X and Theory Y," and McClelland's "The Urge to Achieve."[154]

7.1.3 Mathematical School

.1 The Mathematical School

This school models an organization's systems using mathematical techniques such as linear or non-linear programming. The goal of the modeling exercise is to optimize each system in an effort to maximize that organization's productivity. Modeling an organization's functions is, of course, a formidable task. Nevertheless, proponents of this school forge ahead. Several University Engineering Management (EM) programs focus on this management approach.

---

[153] For additional information about the Social Systems School, see the following: Robert R. Mouton and Jane Srygly Blake. *The Managerial Grid.* Gulf Publishing, 1968; Rensis Likert. ˆLikert's System Four," Amacom, 1975; Jon R. Katzenbach and Douglas K. Smith. *The Wisdom of Teams: Creating the High Performance Organization*. Harper Paperbacks, 2003.

[154] For additional information about the Human Behavioral School, see the following: Frederick Herzberg, "One More Time: How Do You Motivate Employees," *Harvard Business Review*, January- February, 1968; Abraham H. Maslow, "A Theory of Human Motivation," *Psychological Review*, 1943; Douglas M. McGregor, "The Human Side of the Enterprise," *Management Review,* November, 1957; David McClelland, "That Urge To Achieve," *Think Magazine*, 1966.

.2 Decision Theory School

Decision Theory identifies a situation and its range of possible outcomes and then formulates the strategies an organization could use to respond to each. Decision rules are applied to determine which strategy would yield the best result for the broadest array of possible outcomes. Probability of the occurrence of each outcome is estimated and enters into the decision process.

Take, for example, a university trying to determine how it will fund research in an election year. If a Democratic candidate should win, environmental research may be funded at a higher level. If the Republican candidate should win, new weapons systems may receive additional funding. Any proposed research programs that have elements of both areas may get a more serious look. For instance, if a crop sensing satellite program is proposed, it could also be used to check the growth of drug fields in Afghanistan. This has elements of environment, culture and defense and might receive a higher priority. Otherwise, researchers would be encouraged to submit environmental research projects that a democratic administration would be more likely to fund.

.3 Scientific Management

The next major development in management theory was Frederick W. Taylor's Scientific Management.[155] Taylor was one of the founders of the field of Industrial Engineering. He worked at several major companies, primarily in the steel industry, and his work led to large improvements in productivity. He developed four management principles that led to these production improvements:

1. Develop a large collection of knowledge about the process under study. Use this knowledge to determine the one best way to perform the work.
2. Scientifically select workers who are most able to perform the work by the specified method.
3. Train the workers to do the work using the "one best way." Provide incentives for using the correct method.
4. Let management and workers collaborate on decisions so that the unique knowledge each has can be utilized when solving organizational problems.

The overriding assumption in these four principles is that management divides the work (i.e., creates a division of labor) and makes decisions affecting the way work is done. Taylor believed that if any task is studied sufficiently, management can determine the one best way for doing it and, thus, optimize productivity. Further, he believed that the variation introduced by the workers could be reduced to insignificance through training and incentives. Workers and machines were seen as only slightly different.

Summary

The field of Engineering Management is dominated by knowledge workers, professionals and talented technical personnel. As Argyis points out, classical management concepts were

[155] Taylor, Frederick W., *Shop Management.* Harper and Brothers. New York, 1911.

developed for unskilled workers in an environment controlled by upper management.[156] The question now becomes one of balance between the management concepts and their appropriate relationship to each other, as well as their applicability to the field of engineering management.

7.2 Managing and Motivating Knowledge Workers

People Orientation

The focus of this section is the ”People” block of the Management Model shown in Figure 7-1 above. The people component of an organization undergirds all other components of the model. An organization’s human resources, for example, interact with both the internal and external environments. Similarly, an organization’s structure and systems can only function with motivated and productive knowledge workers.

“Knowledge workers” is a concept first coined by Peter Drucker in 1959. He used the term to define the class of workers that drive today’s information economy. The class includes inventors, innovators, process developers, and process improvers, to name a few examples.

Knowledge workers present a unique challenge to management. Unlike with physical labor, you cannot assess a knowledge worker’s productivity or effectiveness by observation. With mental labor, the value of work being done may not be known for a significant period of time. If the knowledge worker doesn’t feel as if he or she is being treated fairly, rewarded adequately or supported appropriately, the worker may decide to slow the work down or stop working altogether without being detected.

Because job satisfaction is vital to a knowledge worker’s productivity, it is more important than ever to understand the behavioral dimension of management. The knowledge worker wants to be a part of the organization, not just occupy a “slot” on the organization chart, and an effective manager has to understand how to facilitate that desire.

The management model introduced above will continue to guide the thought process throughout this domain. In this section, we will focus on people management, as it is the least known and practiced of the model’s concepts.

Background on Behavioral Approaches

The first years of the twentieth century saw the development of multiple management concepts. The French engineer Henri Fayol, for example, developed the first recorded management principles. Frederick W. Taylor developed Scientific Management to increase productivity. Frank and Lillian Gilbreath developed methods analysis, and Henry Gantt developed the Gantt chart for scheduling large-scale projects.

[156] Argyris, Chris, “The Individual and Organization: Some Problems of Mutual Adjustment,” *Administrative Quarterly*, Vol. 2, June, 1957.

The idea that management practice could improve productivity encouraged many organizations to actively experiment with new management techniques in the hopes of giving themselves a competitive advantage. Western Electric, for example, conducted a wide range of experiments with management practice at its Hawthorne works. They experimented with lighting, work breaks, incentive systems, organization communication and other concepts. The general conclusion was that the attitude of workers had much to do with organizational productivity. They did not, however, reach firm conclusions on how to develop those positive attitudes. Effective theories on workforce motivation required another thirty-five years to develop.

Chris Argyris performed a seminal study of management approaches and concluded that modern management tended to treat workers as children while expecting them to behave as adults.[157] Following Argyris' conclusion, the Engineering Management program must be very careful about what they teach as being acceptable practice.

After World War II, many behavioral theories were developed. The ill-fated "human relations" movement spawned much research that proved beneficial, although still short of being the total answer. The major behavioral concepts applicable to knowledge workers by engineering managers include concepts developed by Douglas McGregor, Abraham Maslow, Frederick Herzberg and David McClelland, each of which is discussed below.

7.2.1 The Impact of Assumptions

.1 McGregor's Theory X and Theory Y

Douglas McGregor, a Harvard professor and business consultant, studied the assumptions management makes about its workers and the impact these assumptions have on worker productivity.[158] He distilled the range of managerial assumptions as follows:

- Theory X - workers must be coerced to work. They are lazy and want security above all else.
- Theory Y - workers are dedicated to organizational objectives and will exercise self-control in order to achieve them. They are responsible and frequently innovative in their approach to solving organizational problems.

McGregor observed that in most cases Theory X becomes a self-fulfilling prophecy. When management crafts work rules as if the workers need close supervision or can not be trusted, workers are likely to act as if they need to be told exactly what to do. In fact, the opposite is usually true: workers frequently know exactly what needs to be done, many times better than management. If, on the other hand, management assumes that its workforce strongly supports the organization, workers are more likely to value the relationship with management and respond to them and their responsibilities positively.

---

[157] Argyris, Chris, "The Individual and Organization: Some Problems of Mutual Adjustment," *Administrative Quarterly*, Vol. 2, June, 1957.

[158] McGregor, Douglas M.: "The Human Side of the Enterprise": Management Review, November 1957.

7.2.2 Identifying and Meeting Employee Needs

.1 Maslow's Hierarchy of Human Needs

Abraham Maslow theorized a five-level hierarchy of human needs.[159]

Self Actualization

Esteem (Pubic and Self)

Membership

Safety and Security

Physiological

Figure 7- 2 Maslow's Hierarchy of Human Needs[160]

According to Maslow, individuals seek to satisfy the needs associated with each of these levels in a sequential fashion. Once the basic Level 1 physiological needs have been met, an individual would then attempt to satisfy the needs associated with safety and security. After satisfying safety and security needs, the individual then seeks membership in a formal or informal organization. This is followed by a search for esteem--both public esteem and self-esteem--which is then followed by the search for self-actualization. Note, the individual in Maslow's schema is not motivated to move onto the next level until he or she has substantially (i.e., 85%) met the needs of their current level.

Maslow's hierarchy is a useful concept for management and its understanding of worker motivation and productivity. As individuals, workers are motivated to advance through the levels of the hierarchy. Management must recognize this and initiate programs to assist in the advancement. The organization as a whole benefits when its members are making these kinds of strides.

It is important that managers be sensitive to an individual's location within the hierarchy. While a manager might be dedicated to the organization at the self-actualization level, many of his or her employees might be seeking to satisfy the needs associated with membership. To best assist the employee, she must recognize where employees are in terms of the hierarchy and then help them develop a course of action that will help them advance to the next level.

7.2.4 Motivator-Hygiene Concept

Frederick Herzberg did research on job satisfaction, initially using accountants and engineers to perform his study.[161] He asked participants to think of a time they were satisfied with their jobs and then identify what they considered the causes of that satisfaction. He then asked for them to think of a time they were *dis*satisfied and list the causes associated with that. He and his researchers recorded the responses and grouped them according to similarities or "thought units." The findings were as follows.

[159] Abraham H. Maslow, "A Theory of Human Motivation," *Psychological Review*, 1943

[160] ibid.

[161] Herzberg, Frederick, "One More Time: How Do You Motivate Employees," *Harvard Business Review*, January- February, 1968

The satisfiers, or motivators, were:

- recognition
- achievement
- possibility of growth
- advancement
- responsibility
- the job itself

The dissatisfiers, or hygienes, were:

- working conditions
- company policies
- relations with the supervisor
- relations with peers
- pay

Herzberg observed that management frequently attempts to use hygienes to motivate the workforce, but an increase in hygienes (e.g., pay) only increases the anticipation of further increases. Costs rise, but motivation and productivity do not. While more difficult for management to apply, motivators are less expensive than hygienes and more likely to promote job satisfaction and productivity. He further observed that while hygienes must be maintained at an appropriate level to prevent dissatisfaction (i.e., maintain neutrality), they alone cannot motivate.

The study has been replicated many times with similar results for subjects in a variety of professions, countries and cultures. A study of blue-collar workers showed similar overall results, although hygienes were of more importance and motivators of slightly less importance than in studies of white-collar workers

7.2.5 Achievement-Affiliation Concepts

.1 McClelland's Need to Achieve

David McClelland studied workers involved in a plant shutdown in Erie, Pennsylvania.[162] A few of those laid off immediately set about finding jobs in nearby towns, frequently utilizing their connections. Most people in this group found work within six weeks. He labeled this group nAchievers (nAch) because of their need to achieve.

The majority of laid-off employees, however, checked with their union several times, inquired if another company would buy and reopen the factory, and read the local want ads. They gathered in small groups to discuss the situation to see if anyone knew of available jobs. The majority of this group was still unemployed after six months. McClelland labeled this group as naffiliators (Naff) for their need to affiliate.

[162] McClelland, David, "That Urge To Achieve," Think Magazine, IBM Corporation, 1966.

McClelland discovered that organizations tend to take on the characteristics of their workers. Some are achievement-oriented, while others are more affiliation-oriented. Management needs to examine its recent recruits to determine what kind of employees they are attracting. Productivity and success are products of its work force, but may not be achievable if the organization has the wrong mix of employees, i.e., a preponderance of nAffiliators, with few nAchievers.

It should also be noted that McClelland has had success in training company workforces to become nAchievers, suggesting that people *can* be trained to achieve.

.2 B. F. Skinner's Operant Conditioning Theory

B. F. Skinner won the Noble prize for science in 1963 for his work on behavioral research. He termed the results of his research the Operant Conditioning Theory.[163]

His theory is as follows:

- Behavior that is rewarded tends to be repeated
- Behavior that is ignored tends to be extinguished
- Behavior that is punished generates a negative, fragmented response

According to Skinner's theory, if a manager sees a behavior that is favorable to the organization, the behavior should be rewarded. The reward may be financial, but might also be a favorable comment, a write-up in the company newsletter, or a mention before employees in the same department. By ignoring the positive accomplishment, the manager runs the risk of "extinguishing" it.

Negative behaviors may be ignored and thereby discouraged as long as positive behaviors are rewarded. This does not mean ignoring an employee's violation of rules or failure to follow prescribed processes. They should be dealt with according to policy. It is assumed that many negative comments and attitudes are an attempt to get attention. If the attention is not given, the behavior is likely to be "extinguished."

When punishing offensive behavior, the manager must make sure that the offense merits the punishment. If punishment is dealt that is in excess of the offense, a backlash is likely to occur, perhaps not immediately, but eventually.

Summary

Maslow's Hierarchy of Human Needs, McGregor's Theory X and Theory Y, Herzberg's Motivators and Hygienes and McClelland's Achievers and Affiliators may at first glance seem to be independent concepts, but are actually highly complementary.

For example:

Maslow's Self Actualization and Esteem Needs are closely related to Herzberg's Motivators. Theory Y is a natural way of thinking about employees who tend to be affiliators.

[163] Skinner, B.F., *Science and Human Behavior,* McMillan, New York, 1953.

Those having membership and security needs tend to focus on hygienes, to be affiliators and accurately described by Theory X.

Maslow	McGregor	Herzberg	McClelland
Self Actualization	Theory Y	Motivators	nAchievers
Esteem			
Membership	Theory X	Hygienes	nAffiliators
Security			

Figure 7- 3 Motivation Diagram

In order to motivate knowledge workers, Theory Y must be assumed; self actualization must be encouraged with opportunities; there must be a focus on motivators and achievement.

In order to limit dissatisfaction, membership activities should be facilitated; Theory X assumptions must be avoided and hygienes should be provided at as high a level as can be reasonably afforded.

7.2.5 Management Styles and Group Processes

.1 Relationship Between Classical Management Theory and Productivity in Technical Organizations

The focus of this section is managing knowledge workers in groups or teams. The background for this section is a meta-study by Chris Argyris. He reviewed hundreds of management studies that linked management practices with human behavior.[164]

Most organizations use some version of the standard management practices described in the Management Process School of Management Thought described in the first section. This School espouses the chain of command, unity of command, division of labor, vertical communication channels, authority in accordance with responsibility, etc. Argyris critiqued these management principles. First he researched the common characteristics of personality development. They are:

1. Man develops from a passive infant to an increasingly active adult
2. Goes from a state of dependence to independence
3. Changes from simple behavior to complex with maturity
4. From shallow interests, man develops deep commitments
5. Goes from short time frames to long time frames − more affected by the past than the future

[164] Argyris, Chris, "The Individual and Organization: Some Problems of Mutual Adjustment," *Administrative Quarterly*, Vol. 2, June 1957.

6. Develops from family subordinate to peer or leader
7. Goes from a lack of awareness of self to the development of self control.

Argyris further identifies four common classical organization concepts and compares the result of using them with the traits of normal personality development listed above.

- Division of labor −The individual sells skills rather than total abilities
- Chain of command −This tends to make individuals dependent, passive
- Unity of direction −This is leader oriented, not a function of workers
- Span of control (usually 4 to 8) − Adds levels to the organization, thus increases dependence

Argyris hypothesized three results of using classical organization concepts:

1. There is a lack of congruency between normal personality development and classical organization concepts.
2. This lack of congruency generates frustration, short-term perspective and conflict.
3. The result will be inter-subordinate hostility, rivalries and a focus on parts of the organization rather than the whole.

7.2.6 Defined Management Systems

.1 Likert - An Integrating Principle

Rensis Likert (1961) was an international management consultant, theorist and author. He worked with organizations all over the world and used his experiences to develop management theories, three of which will be discussed in this section.

- Principle of Supporting Management
- Team Management
- Four Systems

He documented the concepts used by the most successful organizations and continuously compared them with those of less successful organizations. He concluded that high-producing organizations and their managers managed differently than managers of low-producing organizations. In general, managers using classical management theories were less successful than those managers who managed in a way that will be discussed below.

.2 Characteristics of High-Producing Organizations

- There are favorable attitudes of members of an organization toward superiors, toward the work, toward the organization. There is mutual confidence and trust throughout the organization.
- There is a high sense of involvement in the achievement of high goals and there is a sense of dissatisfaction if goals are not met.

- The organization effectively harnesses all of the major motivational concepts including:
  - ego motives
  - security motives
  - creativity and curiosity
  - economic motives
- The organization consists of a tightly knit, effectively functioning social system. Employees want to work together, solve problems and make the organization successful.
- The system is made up of interlocking groups with a high degree of group loyalty and with favorable attitudes and trust between subordinates and superiors.
- Measurements of organizational performance are primarily used for self guidance rather than for super-imposed control. This is more of a Theory Y approach within an nAchieving work force.

.3 Characteristics of Low-Producing Organizations

- Motivation is achieved by the exercise of control through authority, i.e., traditional management.
- Jobs are organized, methods are prescribed, standards are set, performance goals and budgets are set by management. (Remember worker dependence and the result?)
- Compliance is sought through the use of hierarchical and economic pressure. This is a Theory X assumption that this is the only way to get workers to produce.

In short, those managers who demand success don't get it. Those managers who allow employees to be successful are more likely to be in a successful organization.

.4 High Producing Managers

Below are the perceptions employees in productive organizations have towards their superior:

- Supportive, friendly, helpful, not hostile
- Displays confidence in subordinate's integrity and ability
- Has high expectations of subordinates
- Coaches and assists employees whose performance is below expectations

This type of manager is *with* his or her employees, rather than just being *above* them. This manager is heavily involved with both the work and the employees.

.5 Traditional Organization

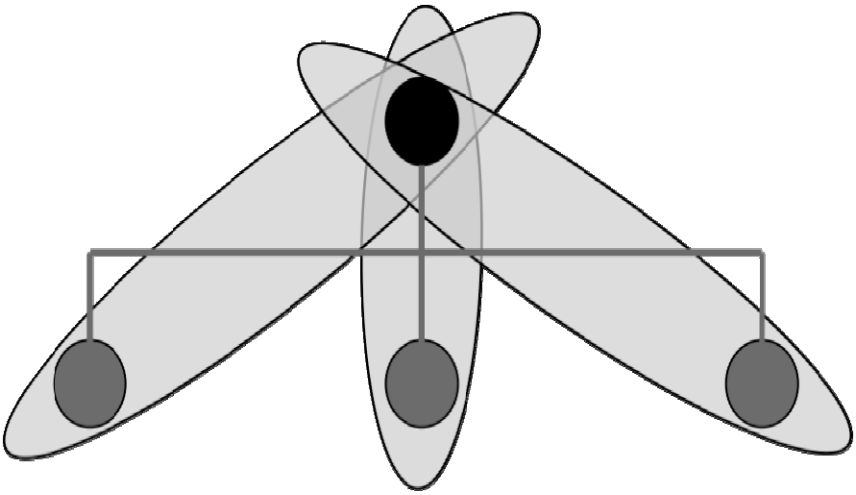

Figure 7- 4 Traditional Organization Structure

In a traditional organization structure (Figure 7-4):

- The boss has a one-on-one relationship with each subordinate. Each subordinate attempts to use whatever means available to extract more resources from the boss than other subordinates receive.
- Communication from subordinate to boss is highly filtered. The boss hears only what the subordinate wants the boss to know in order to receive favor for his or her unit.
- There is mistrust between subordinates who each consider that other subordinates are better treated.
- The good of the organization as a whole receives little consideration. Decisions are made in a vacuum with each unit competing for resources.
- Each unit staffs for the maximum contingency. There is little sharing of resources between units.

This is the way unenlightened managers deal with their employees. This is frequently true organization wide. They know no other way of supervising.

.6 The team-based organization.

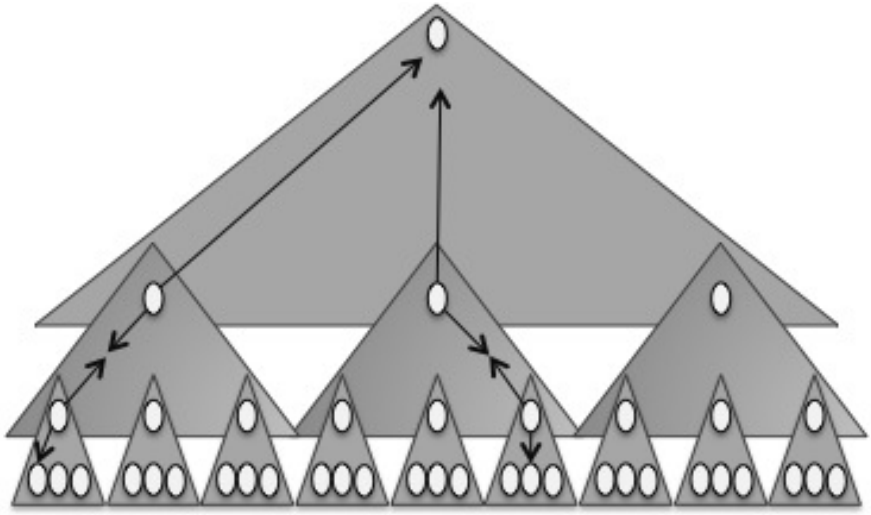

Figure 7- 5 The Team-based Organization

The team-based organization structure (Figure 7-5) is an alternative to the traditional organization structure. It is characterized by the following qualities:

- The good of the organization as a whole is easy to relate to.
- Communications are with the whole group; filtering is not possible.
- Vigorous debate focused on the issues generates better decisions.
- Sharing of resources is looked upon with favor as it allows unnecessary unit cost to be reduced by loaning employees to units in greater temporary need.
- Decisions are better supported. Even those whose recommendations are not followed had input and know the other positions and can generally support the decision.

The Linking Pin is a leader to a group who is also a member of the team at the next highest level. The organization is "linked" together by these "linking pins." This is in contrast to the typical top-down approach that does not value upward or lateral communication patterns. The "linking pins" improve total organizational communication.

Communication loss from the top level down within a traditional organization is represented in the chart below (Figure 7-6).

Communication From → To	**% Message Lost**
Top Management → Middle Management	67%
Top Management → General Manager	50%
Top Management → Supervisor	33%
Top Management → Worker	20%

Figure 7- 6 Message Loss in Top-down Communications

This indicates that those at the base of the traditional organization receive very little accurate information emanating from the top. The real question is: "What are the similar percentages going from the bottom to the top level?" As this generally does not happen, it is zero. Likert's "linking pins" facilitate this upward communication, and in this sense is better than the limited uni-directional communication available within a traditional organization.

7.2.6 Likert's System IV

The researcher Rensis Likert carefully observed and analyzed a wide array of organizations in order to develop his schema of management styles.[165] The schema consists of four management systems, each of which is described below. Of the four, he concluded that only System IV achieves normal productivity goals consistently.

.1 Likert's Four Systems

- System I: Exploitive - Authoritative
- System II: Benevolent - Authoritative (we have your best interest at heart)
- System III: Consultative - Democratic
- System IV: Participative - Democratic

Likert evaluated each system according to the following criteria:

1. **Leadership Processes**: The extent to which superiors have confidence and trust in subordinates.
2. **Character of Motivational Forces**: The forces used to motivate employees. Can include the promise of physical security and fulfillment of economic needs to achievement of satisfaction derived from teamwork.
3. **Character of Communication Process**: The amount and direction of communication aimed at achieving organizational objectives.
4. **Character of Interaction Influence Process**: How do different levels of an organization work together to solve problems and achieve objectives.
5. **Character of Decision Making Process**: At what level in the organization are decisions made?
6. **Character of Goal Setting**: Where are goals established and from what level do orders normally come?

[165] Likert, Rensis; *New Patterns of Management*, McGraw Hill, Inc., New York, 1961.

The findings are listed in Figure 7-7 below.

AREAS OF DIFFEREN-TIATION	SYSTEM 1 Exploitive Authoritative	SYSTEM 2 Benevolent Author.	SYSTEM 3 Consultative	SYSTEM 4 Participative Group
Motivational Forces	Taps fear, need for money, and status. Ignores other motives, which cancel out those tapped. Attitudes are hostile, subservient upward, contemptuous downward. Mistrust prevalent. Little feeling of responsibility except at high levels. Dissatisfaction with job, peers, supervisor, and organization.	Taps need for money, ego motives such as desire for status and for power, sometimes fear. Untapped motives often cancel out those tapped, sometimes reinforce them. Attitudes are sometimes hostile, sometimes favorable toward organization, subservient upward, condescending downward, competitively hostile toward peers. Managers usually feel responsible for attaining goals, but rank and file do not. Dissatisfaction to moderate satisfaction with job, peers, supervisor, and organization.	Taps need for money, ego motives and other major motives within the individual. Motivational forces usually reinforce each other. Attitudes usually favorable. Most persons feel responsible. Moderately high satisfaction with job, peers, supervisor, and organization	Taps all major motives except fear, including motivational forces coming from group processes. Motivational forces reinforce one another. Attitudes quite favorable. Trust prevalent. Persons at all levels feel quite responsible. Relatively high satisfaction throughout.
Interaction-Influence Process	No cooperative teamwork, little mutual influence. Little upward influence. Only moderate downward influence, usually overestimated.	Very little cooperative teamwork, little upward influence except by informal means. Moderate downward influence.	Moderate amount of cooperative teamwork. Moderate upward influence. Moderate to substantial downward influence.	A great deal of cooperative teamwork. Substantial real influence upward, downward, and laterally.

AREAS OF DIFFEREN-TIATION	SYSTEM 1 Exploitive Authoritative	SYSTEM 2 Benevolent Author.	SYSTEM 3 Consultative	SYSTEM 4 Participative Group
Goal-Setting Process	Orders issued. Overt acceptance. Covert resistance.	Orders issued, perhaps with some chance to comment. Overt acceptance, but often covert resistance.	Goals are set or orders issued after discussion with subordinates. Usually acceptance both overtly and covertly, but some occasional covert resistance.	Goals established by group participation, except in emergencies. Full goal acceptance, both overtly and covertly.
Communication Pattern	Little upward communication. Little lateral communication. Some downward communication, viewed with suspicion by subordinates. Much distortion and deception.	Little upward communication. Little lateral communication. Great deal of downward communication, viewed with mixed feelings by subordinates. Some distortion and filtering.	Upward and downward communication is usually good. Lateral communication is fair to good. Slight tendency to filter or distort.	Information flows freely and accurately in all directions. Practically no forces to distort or filter.
Decision-Making Process	Decision made at top, based upon partial and inaccurate information. Contributes little motivational value. Made on man-to-man basis, discouraging teamwork.	Policy decided at top, some implementation decisions made at lower levels, based on moderately accurate and adequate information. Contributes little motivational value. Made largely on man-to-man basis, discouraging teamwork.	Broad policy decided at top, more specific decisions made at lower levels, based upon reasonably accurate and adequate information. Some contribution to motivation. Some group-based decision making.	Decision making done throughout the organization, linked by overlapping groups, and based upon full and accurate information. Made largely on group basis, encouraging teamwork.

AREAS OF DIFFEREN-TIATION	SYSTEM 1 Exploitive Authoritative	SYSTEM 2 Benevolent Author.	SYSTEM 3 Consultative	SYSTEM 4 Participative Group
Control Process	Control at top only. Control data often distorted and falsified. Informal organization exists, which works counter to formal, reducing real control.	Control largely at top. Control data often incomplete and inaccurate. Informal organization usually exists, working counter to the formal, partially reducing real control.	Control primarily at top, but some delegation to lower levels. Informal organization may exist and partially resist formal organization, partially reducing real control.	Widespread real and felt responsibility for control function. Informal and formal organizations are identical, with no reduction in real control.

Figure 7- 7 Likert's Four Systems Compared

No one has surveyed the population of contemporary organizations to determine the current distribution of these management systems, but it is widely believed that most organizations are System II. A few organizations abide by System III, while the existence of System IV organizations is rare.

Likert believed that in determining the value of an organization, the value of the human asset must be assessed. Human asset value consists of:

- Recruiting costs
- Training costs
- Familiarization costs
- Capability costs
- Development costs.

A layoff is a liquidation of valuable assets just as surely as selling equipment, land, facilities or inventories. All of the costs listed above are lost when human resources are liquidated. Many of these costs will have to be paid again, at a higher rate, without the guaranty that the work will be done as well.

Likert's general conclusion is that attitudes and skill generate productivity. He observed an organization's management system drives a worker's attitudes and attitudes generate productivity and profits. In other words, management systems have a significant impact on productivity and profits.

System IV has much in common with Theory Y, Self Actualization, and Motivators, all of which are discussed above.

7.2.7 Blake and Mouton's Managerial Grid

In the late 1960's, Dr. Robert Blake of the University of Texas studied the management of a major corporation at their corporate headquarters.[166] The commonly accepted theory of the day was that management style cold be categorized on a continuum from autocratic to participative. Blake and Mouton sought to either validate this theory or develop a new one.

They observed that some managers were very successful and managed productive units. They were observed to have similar management styles. Others managers that were in charge of less successful units also had similar management styles. Neither management style fit into the autocratic-participative continuum. Further observations were made of some successful managers who were transferred to units with productivity problems. These units improved over a period of time to be similar to the unit the successful managers had left.

The Managerial Grid (Figure 7-8) is the theory that they developed to describe the results of their study.

.1 The Managerial Grid

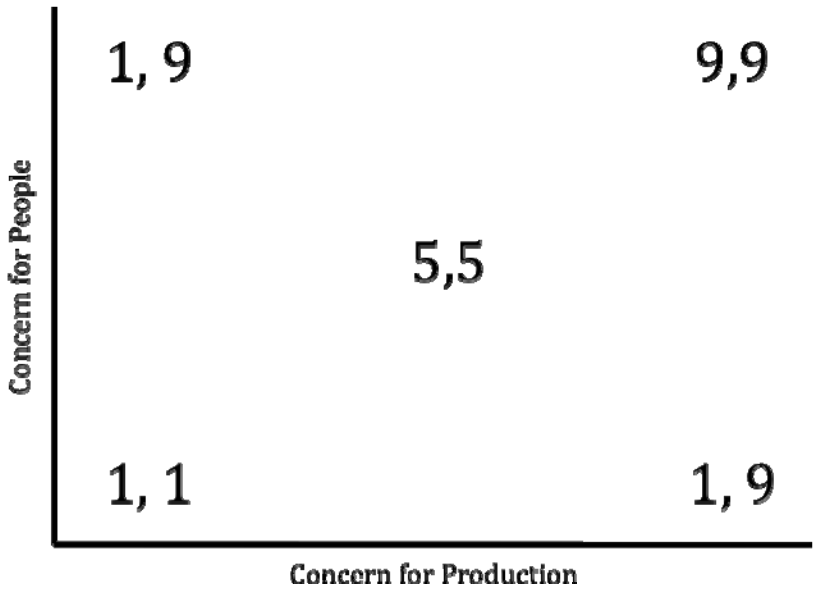

Figure 7- 8 The Managerial Grid

Definitions of the positions on the Managerial Grid

Five positions on the grid are adequate to demonstrate the array of common management styles:

1-1 These managers avoid decisions and use "policies" instead of positions. They hide behind policies and avoid confrontation. They are not oriented toward production either. They stay in their offices frequently. Their approach to conflict resolution is to ignore the conflict.

[166] Blake, Robert, and Mouton, Jane, *The Managerial Grid*, Gulf Publishing Co., Houston, 1964.

1-9 Sometimes referred to as country club management style, these managers' make decision to make their employees happy as opposed to addressing issues and solving problems. They hope that production will take care of itself if employees are content. They attempt to meet goals by manipulating employees. Conflict resolution is to sweep problems "under the rug."

9-1 This is an autocrat management style. These types of managers solve problems by edict. Production is their first priority. People are hired to get the work done. Their approach to conflict resolution is "my way or the highway."

5-5 This type of manager views people and production equally, but is not particularly strong on either. This is a bureaucratic, status-quo position. There are more managers in this position than all others according to standardized tests. They tend to solve problems by compromise.

9-9 This is the team manager position. These managers use employees as teams to gather and share information and to identify and solve productivity problems. There is a natural balance between people and production. These managers' teams solve problems by confronting them.

Results

Only managers with strong concerns for both people and work were in high productivity units.

- These managers used teams extensively
- Confronted issues to resolve conflict
- Received extensive input from employees
- Developed employee capabilities

Summary

All of the studies discussed above reach similar conclusions (Figure 7-9). Argyris shows that traditional management does not work very well. Efforts to get high productivity under classical principles are not successful. Likert's System IV had similar constructs and results as Blake and Mouton's Managerial Grid 9-9 position.

Managers making a Theory Y assumption and a focus on motivators will likely use Likert's System IV and have a 9-9 management style on the Managerial Grid.

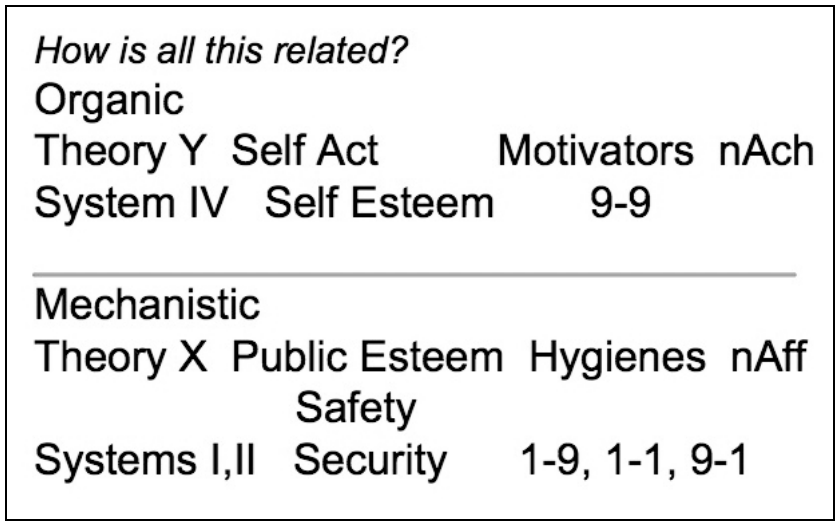

Figure 7- 9 Comparing the Results of Key Management Studies

7.3 Organization Structure

This section concerns the "Organization Structure" block at the center of the management model depicted in Figure 7-1 above. In order for an organization to restructure successfully, its managers must understand the characteristics of potential structural alternatives. That understanding is the purpose of this section.

Structure is the mechanism that an organization uses to carry out its mission. If the structure and the mission are not compatible, problems will surface in communication and coordination. This has to do with how the structure functions, in an organic or mechanistic way.

7.3.1 Organic vs. Mechanistic Structures

.1 Burns and Stalker Study

The first major research study of organizational structure was by Burns and Stalker in England.[167] In their study, environment was divided into three classes: stable, changing and innovative. The study establishes the relationship between stability of the environment and the organization's structure and operation.

1. Stable environment:

- Stable demand
- Unchanging competitive landscape
- Low level of product change or innovation

Resulting organizational structure and operation:

- Centralized decision making
- Production controls

[167] Burns, Tom, and Stalker, G.M., *The Management of Innovation*, London, Tavistock, 1961.

- Functions rigidly adhere to job descriptions
- Emphasis on chain of command, rules
- Geared for efficiency and cost minimization.

2. Changing environment:

- Fluctuating demand but within limits − somewhat predictable
- Changing competitive landscape
- Changing product or service,
- Government regulations change but can be anticipated

Resulting organizational structure and operation:

- Jobs are not rigidly defined; they are more general, flexible
- Communication outside the chain of command is tolerated
- Coordination is aided by committees
- Emphasis on response to customer need

3. Innovative environment:

- Demand is volatile; change happens suddenly and without notice
- Competitive landscape changes quickly and dramatically
- Rapid rate of change in products or services
- Organization is dependent on research and development
- Government policies are evolving and end position is unclear

Resulting organizational structure and operation

- Structure where employees are driven by goals as opposed to specific tasks
- Employees are flexible with regards to roles and responsibilities. Main focus is project or organizational goal, not a specific, pre-defined set of tasks.
- Communications are frequent to allow quick response to environmental change
- There are few pre-established organizational "rules"

.2 Mechanistic vs. Organic

Burns and Stalker further observed two classes of organizational behavior that were linked to structure. They termed the two classes organic and mechanistic. These terms are defined as follows.

- Mechanistic: Mass-producing organizations that experience a low rate of change
- Organic: Technologically-sophisticated organizations that experience high rates of change

The following lists provide some insight into the characteristics of each of these organization types.

Mechanistic Organizations

- Close adherence to a chain of command
- A functional division of work, through which the organization's problems are broken down and managed
- Each task is of a highly specialized nature
- Work coordinated via a formal hierarchy
- Detailed job description provide a precise definition of rights, obligations and technical methods for each job
- Employee interactions tend to be vertical, between a superior and a subordinate
- Operations and working behavior governed by the instructions and decisions issued by superiors

Organic Organizations

- Little adherence to a chain of command
- A more flexible, divisional type of work
- Each person's responsibility understood as being broader than a limited set of rights, obligations and techniques. No more "that's not my job."
- Jobs are not clearly defined in advance but instead continually adjusted and redefined as the situation demands
- Communication occurs laterally, or via a network or matrix structure, rather than vertically
- Consultation emphasized over commands; communication generally consists of information and advice rather than instructions and decisions
- Employees motivated by a pervasive commitment to the organization's goals, as opposed to the system of rewards and punishment that define a mechanistic organization

7.3.2 Typical Structure Types (Departmentation)

Dessler defined departmentation as "the process through which [an organization's] activities are grouped logically and assigned to managers. It results in departments - logical groupings of activities - which also often go by the name of divisions, branches, units or sections."[168]

There are three basic types of departmentation:

- Functional (process)
- Divisional (product, geographical, industry)
- Matrix

[168] Dessler, Gary, *Organization Theory: Integrating Structure and Behavior*, 2nd ed., Prentice Hall, New York, 1986.

It should be noted that most organizations are some mixture of these departmentation types. Large organizations—those with over 1,000 employees—tend to be the exception; they are almost always functional.

Each of the departmentation types is discussed in detail below.

.1 Functional

Small organizations usually start out with a functional departmentation structure. Most departments contain similarly trained personnel, e.g., departments of accountants, engineers, purchasing specialists, manufacturing personnel, etc. The focus of the organization is efficiency.

This structure is based on a division of labor with a strong chain of command and managers with spans of control limited to one or a few of the organization's functions. Both communication and coordination are difficult in large organizations because there is only one common manager – the one at the top. This structure works best in a low-technology environment. It uses strong rules and procedures for coordination. Training is easy because all like employees are in the same group. Primary feature: centralized executive control.

In these organizations, environmental changes can overwhelm the top executive, as he or she has a narrow scope of functional experience. Succession of the top executive is also difficult to plan for, as few people within such organizations have insight into all of its key functions.

.2 Divisional

Divisions are copies of the original parent organization. Each division has its own support staff, suppliers and customers. The division is tied financially, in some manner, to the parent. If additional resources are needed, the first source is usually the parent. If the parent does not supply the needs, it has the option to abandon the project or to seek external sources of funding. Each division can succeed or fail, depending on its own efforts.

Large division organizations, such as those of major auto companies, do not behave like true divisions. They are so large, that they act as if they are functionally organized. Johnson and Johnson, with its 200+ divisions is the example most cited as a true divisional organization. They try to grow by forming new divisions that are successful while shutting down those that do not make a profit.

Product Division Characteristics

- Decentralized decisions
- Easier evaluation - based on accomplishment
- Organization focuses on products or services, not individual departments.
- Produces general managers
- Responds more quickly to changes in the environment
- Requires duplication of resources

General rules

It is appropriate to use functional organization when:

- Efficiency is more important than responsiveness
- Narrow groups of unchanging products and customers
- Stable environment, low technology, small organization
- The organization is small

There is always a part of an organization that is functional. It is not a handicap in the lower levels or in small organizations.

Use a divisional structure when:

- New products or services are likely to be added to the organization
- When flexibility is required for decision makers
- When profitability depends on the development of new products or services

Implications for Coordination (for divisions or functional organizations)

- For routine predictable tasks, use rules.
- The more interdependent organizational units are, the more difficult coordination is to achieve.
- The more diverse the goals of the organizational units, the more difficult coordination is to achieve.
- The more there are unexpected problems, the less reliance should be placed on rules for coordination.

.3 Matrix

This is the project-based structure. Project managers manage projects including project finances, project personnel and project customer relations. Functional managers provide the projects with manpower from their specialized departments. They also are responsible for the professional development of their employees, as well as personnel-related matters such as evaluations. Each project employee is responsible both to the project manager and the functional manager. Each employee may work on several projects simultaneously. (Note: Engineers working on multiple projects have been blamed for mistakes that caused serious accidents in construction projects.)

The matrix organization violates some of the classical management concepts.

- **Authority should be equal with responsibility**. The project manager has all of the responsibility for a project but frequently does not have the authority to take appropriate action. The functional manager exerts control through personnel assignment to projects.
- **Unity of command.** Every one in a matrix team has at least two bosses − the project manager and the functional manager.
- **Division of labor**. The functional departments tend to dominate project teams and division of labor remains intact.

Typical problem areas within the matrix structure are as follows:

- **The functional organization does not understand its proper role in the matrix**. Because of the functional organization's project-related obligations, it frequently must

neglect its knowledge-base responsibilities (e.g., maintaining the knowledge base, deciding what skills will be needed in five to ten years, deciding what skills to develop in its employees, and which to obtain through hiring from the outside, etc.). The functional manager does not adequately fulfill the responsibilities of his role.

- **Evaluation of employees**. Who does this, project manager or functional manager? It should be a team effort, but the functional manager frequently does it in a vacuum.
- **Who picks team members?** The functional manager might assign employees to projects based on that manager's priorities, not based on the employee's suitability for the specific project. In other words, staffing frequently optimizes the needs of the functional department, not the needs of the project**.**
- **Leadership style of the PMs**. Inadequate training of the project manager is the norm. They are frequently expected to perform without being given proper tools, education or resources.
- **Support systems.** In order to make adequate decisions, the project manager must know how much has been charged to his or her project in terms of time and dollars. The organization frequently does not provide the PM with the support it needs to track these charges.
- **Inadequate follow up**. The question "What did we learn from past projects that we can apply to future projects?" is often difficult to answer in a matrix structure, making it hard for the organization to learn from past mistakes. The reason the question doesn't get asked/answered has a lot to do with the frequent coming and going of employees on a given project, i.e., few employees who start the project are there at its end.
- **The larger the organization, the more difficult it is to run the matrix**. Successes tend to be in smaller organizations. Many organizations attempt to put ten layers of bureaucracy on top of a matrix. This is a particularly deadly combination.

7.3.3 Models of Structures

Mintzberg's Organization Design

Henry Mintzberg proposed a different model for organization structure.[169] His model contained five common elements that have different sizes and functions depending on the structure's purpose. He observed that structures for professional offices, for instance, are different from those of mass manufacturers.

Each of the basic elements on Mintzberg's model are shown in Figure 7-10.

[169] Mintzberg, Henry, *The Structure of Organizations*, Prentice Hall, Englewood Cliffs NJ, 1979.

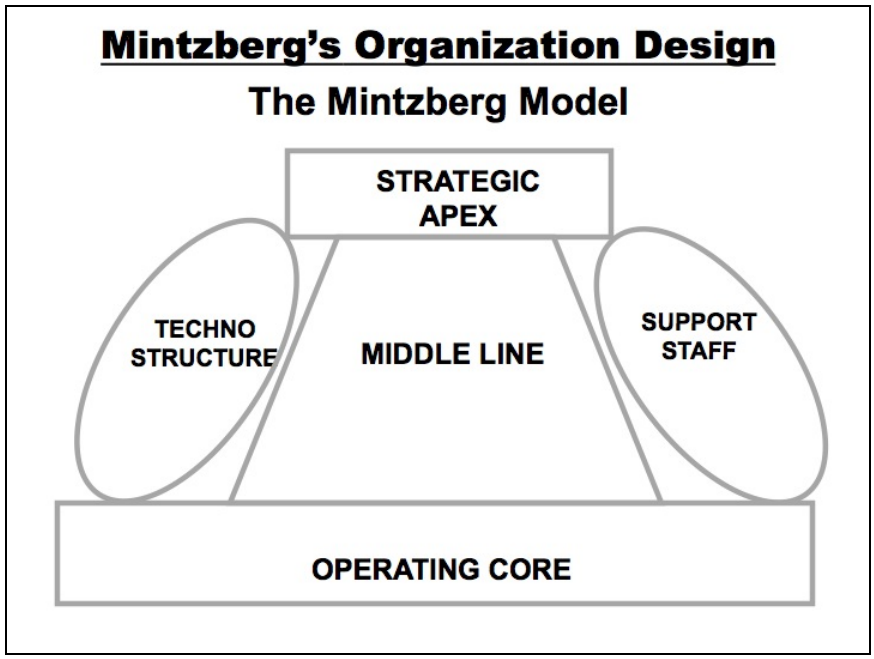

Figure 7- 10 The Mintzberg Model[170]

The five elements are:

- Strategic apex
- Middle line
- Operating core
- Technostructure
- Support staff.

Each of the elements is described below.

The Strategic Apex includes

- The Board of Directors
- The President or CEO
- The President's staff
- Board Committees

The Middle Line links Upper Management with the Operating Core. It includes

- Vice President for Operations
- Vice President for Marketing
- Plant Managers
- Regional Sales Managers

[170] Mintzberg, Henry, *Structures in Fives: Designing Effective Organizations*, Prentice Hall, Englewood Cliffs NJ, 1983.

Technostructure is comprised of the staff groups that support the Operating Core**.** A large technostructure is required to standardize work processes, increase efficiency, implement automation, and issue reports on cost and competitive position. Training is included here as an effort to increase productivity.

Support Staff offer services to the organization as a whole. These include:

- Legal Counsel
- Public Relations
- Human Resources
- Payroll, Purchasing
- Mail
- Cafeteria

The Operating Core is composed of those who are doing the work that meets the primary goals of the organization. They are getting the job done and provide the value add of the organization. They provide the basic service of the organization. In an engineering firm, engineers form the operating core; accountants in an accounting firm, etc.

Mintzberg's five basic elements are found in all organizations. The relative size and significance of each element can be used to characterize and/or recognize the particular type of structure. There are five basic types of configurations, all of which are described below.

Five Basic Configurations

.1 Simple Structure

The simple structure has a top and bottom without a middle line. This is how many organizations begin. The owners do everything. There is no need for additional people until it is justified by growth. Growth comes easily in this streamlined structure.

Communication throughout the organization is natural.

.2 Machine Bureaucracy (MB)

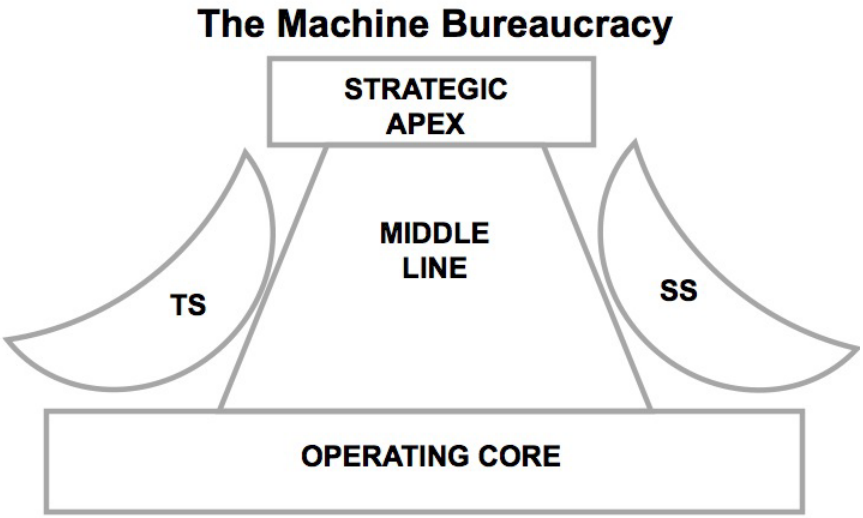

Figure 7- 11 The Machine Bureaucracy[171]

The Machine Bureaucracy (MB) is characterized by a large middle line and technostructure. Control and efficiency through standardization are emphasized. Communication is typically through top-down channels and comes from either higher management or powerful staff groups. Organizations that have mass production of standard products are most likely to use this structure. Tasks are highly specialized, routine and controlled by procedures, rules and policies. The Middle Line ensures that procedures are carried out, handles disturbances from workers, and act as liaison between the technostructure staff groups and workers in the Operating Core.

The emphasis is on efficiency; changes in product, environment and innovation are slow in evolving. If the environment changes rapidly--such as when a competitor introduces a revolutionary new product--the machine bureaucracy responds slowly. It is more likely to lower prices to keep customers from buying the new product. Developing a competing product will take a relatively long time.

.3 The Professional Bureaucracy (PB)

The Professional Bureaucracy (PB) organization is dominated by the skills and abilities of the Operating Core. Medical organizations, legal firms, accounting firms and universities have been described as Professional Bureaucracies. The Technostructure is small because most of the organization skills are in the Operating Core. The Support Staff is large in order to give the Operating Core enough support to be effective. The Strategic Apex is small compared to other structures. They have less real power due to the expert power residing in the OC.

[171] ibid.

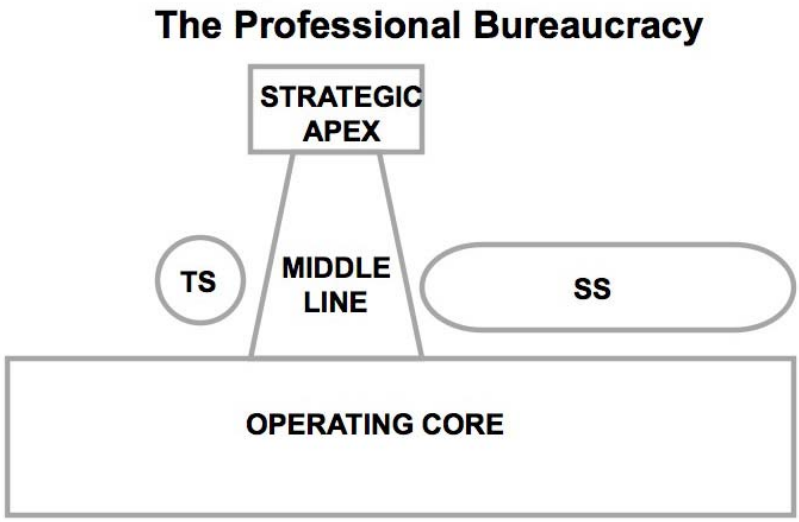

Figure 7- 12 The Professional Bureaucracy[172]

The environment is both complex and stable. Changes are usually accommodated by hiring those with the necessary skill sets. Internal change is slow and communication fragmented along specialized skill lines. General, organization-wide communication is lacking.

.4 Divisionalized Form (DF)

The Divsionalized Form (DF) is utilized in companies that have self-contained divisions that are similar in nature to the parent corporation**.** A classic example is a company like GM where both the parent and its divisions are machine bureaucracies. Companies like Johnson and Johnson have many (160) small organic divisions. The parent has a small technostructure and large support staff, while the divisions have a technostructure that is very different from the parent and is unlikely to have a corporate support group. The divisions are normally similar to each other, but may or may not be similar to the parent.

There are two types of divisionalized forms: large bureaucratic parents with large bureaucratic divisions or organic parents with similar, smaller, more organic divisions.

.5 The Adhocracy

Burns and Stalker identified the need for a flexible organic structure. This is the adhocracy. The adhocracy is an organization that is composed of cross-functional teams that change with the needs of the organization. The nature of the adhocracy is for employee roles to continually change with specific projects. Thus, it is a continually innovating structure. WL Gore and Associates is an example of an adhocracy. Teams work on product development with team members doing the tasks needed by the project. Connection to upper management is more consultative than by mandate.

The matrix structure was intended to be adhocratic; however, it did not work out that way.

---

[172] ibid.

The Operating Adhocracy.

Multi-disciplined teams innovate and solve problems directly on behalf of clients. The operating adhocracy engages in creative effort to find novel solutions to client problems. Administrative and operating work tends to blend into a single effort. The organization employs experts who are available to project teams as needed.

The Administrative Adhocracy

The operating core is separated from the Strategic Apex and Middle Line. Projects are managed by the adhocracy, but the operating core is contracted or outsourced. This allows the organization to contract with the best organization for a particular project.

Management in an Adhocracy

Managers exercise little supervision. They are more consultants than supervisors. They are available to assist project teams individually or in combinations.

Many organizations attempt to form adhocratic teams when problems are complex or the solution direction is unknown. Most of the time, management attempts to regain control somewhere along the way. Successful teams identify a problem, are separated from conventional management and allowed to pursue solutions independently. This is the definition of a true team.

Summary

Organization structure, though not well understood, is a critical part of successful management. It is the middle element of the management model and touches every other element. Structure does not operate in a vacuum and must be responsive to the environment in which it exists and operates. The structure must serve the mission of the organization.

If the organization's environment is marked by speed and rapid change, then an organic structure is needed. It requires that management treat employees as if they were responsible and productive (Theory Y), as well as incorporate a system such as Likert's System IV or a 9-9 approach on the Managerial Grid. nAchievers should be hired, promoted and encouraged, and motivators deliberately provided. Hygienes should be maintained at a high level.

If, on the other hand, the environment is slower-paced without an emphasis on technology production, other more mechanistic structures may work adequately. Heavy manufacturing, for example, may use a Machine Bureaucracy with its emphasis on cost control and efficiency.

7.4 Management Systems and Systems Thinking

The Systems Context

"Systems," the first of the middle elements in the Integrated Management Model, is narrowly defined as an organization's efforts to align its operational elements with a particular management philosophy. This includes such systems as Total Quality Management, Lean Enterprise, Six Sigma and others. All such systems are undergirded by a fundamentally

sound philosophy, yet most of those implemented in the past twenty years have failed, lasting only one or two years each. This section provides some answers as to why those systems failed despite the soundness of their undergirding principles. Much of the material here is derived from the book *The Fifth Discipline* by Peter Senge.[173]

A famous quote from Machiavelli seems appropriate:

> It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiator has the enmity of all who would profit from the preservation of the old institutions and merely lukewarm defenders in those who would gain by the new ones.[174]

Improving existing systems, as well as implementing new ones, generates organizational friction that the organization must overcome. Sources of improvements in systems frequently involve technology application and/or improved communication. The Fifth Discipline deals primarily with communication and ways to use it to increase the commonality of goals and the use of conceptual thinking.

7.4.1 Systems Thinking

Metanoia — a shift of mind.

According to Senge, Systems Thinking requires a new way of thinking about an organization. He uses the Greek term "metanoia" to describe this approach. Metanoia, often used in a religious context, means a fundamental change in the way we look at things. In the context of organizational change, it means seeing all of an organization's functioning systems as linked together.

Each system in an organization affects others, frequently in unexpected ways. Elihu Goldratt wrote his best selling instructional novel, *The Goal*, to illustrate this principle.[175] He demonstrated that an organization produces only as fast as its slowest process. This impedes the productivity of those processes that are capable of producing more quickly. His remedy is to continue to improve the limiting processes. This rationale is an example of taking a systems view.

Senge points out that the Douglas DC-3 airplane effectively integrated five systems that had never been combined on a single airplane. Except for the engine system, all modern aircraft have these technologies in use. The combination of technologies has the potential to produce innovative products. This is possible, even encouraged, by systems thinking.

---

[173] Peter Senge, *The Fifth Discipline Field Book Strategies and Tools For Building a Learning Organization*, New York, NY, 1994.
[174] Machiavelli, Niccolo, *The Prince*, Oxford University Press, New York, NY, 2008.
[175] Goldratt, Elihu, *The Goal*, North River Press, Second Edition, 1992.

Systems Thinking Disciplines

To view an organization in terms of its functioning systems, Senge employed five disciplines. They are:

- Systems Thinking ─ learning to view connected events as a system
- Personal Mastery ─ the continuous individual improvement necessary to improve the organization
- Building Shared Vision ─ identifying what the organization is capable of becoming and having everyone understand and agree on that direction; a shared vision guides managerial decisions
- Team Learning ─ the organization's intelligence is directly related to its members' ability to act in consort. That ability must increase faster than it does at major competitors.
- Mental Models ─positive, accurate views of the organization and its direction must become ingrained in order for it to be successful

Systems thinking is the fifth discipline. It binds all others together. It is the ability to view connected events as a part of a functioning system. Failure to see the interconnectedness of systems frequently leads to a system's failure. Prison systems, for example, do not always reform their inmates. Once released, many offend again and return to prison. The welfare system is frequently accused of making its recipients dependent on its benefits. The recipients tend to stay in the system for generations rather than becoming self-sufficient. Both systems are intended to be short-term solutions, but neither effectively achieves that goal. The failure is related to the inability to see the system's complexity and its interconnectedness to other systems. To be effective, systems must be examined and developed in a way that identifies their complex elements and their interconnectedness. It is also vital that actions taken within the system are in line with the shared vision of that system's development.

7.4.1 Organizational Learning Disabilities

Many managers fail to see their organizations as being composed of systems. In fact, most managers are not aware that systems exist. Senge identified this lack of awareness as an "organizational learning disability." The disabilities are as follows.

1. I am my position.

   Isolating positions confounds the formation of a system. Japanese auto manufacturers, for example, use the same sized bolts in engines. US auto manufacturers, on the other hand, use a different size bolt for each stress. The latter requires inventories of many fasteners of different sizes, unnecessarily complicated the production process.

2. The enemy is out there.

   This is the assumption that it is always someone else's fault. Assessing blame on some other group frees us from responsibility and the willingness to improve. There is a general failure to see the system.

3. The illusion of taking charge.

   This is a proactive strategy in which you plow ahead in the absence of information. You assume action must be taken, even if this is not the case. Before acting it is important to first see the problem systematically, then decide if or what action might be necessary.

4. The fixation on events.

   Focus on events clouds your focus on the evolutionary changes that are impacting the system.

5. The parable of the boiled frog.

   Drop a frog in boiling water and it will jump out. Put a frog in tepid water and turn up the heat, and it will stay until boiled. Most problems get gradually worse and the organization adjusts without ever addressing/fixing the base problem. We react to sudden changes, but are generally less capable to addressing slower changes because of our failure to see the system at work.

6. The delusion of learning from experience.

   Many decisions have effects that are evident only years later. We do not experience these effects, and thus we do not learn from them.

7. The myth of the management team.

   Management teams are used mostly to solve routine problems. They tend to break down under pressure. They tend to focus on compliance rather than focusing on problems in the current system.

8. Disabilities and disciplines.

   This is failure to see the effect of policies and act in the organization's best interest.

The Beer Game

When placed in the same system, people, however different, tend to make the same kind of mistakes. It is only by analyzing one's place within a system that problems are identified and proper solutions implemented. Everyone "doing their own job" will rarely not solve systemic problems.

This problem is aptly demonstrated by the "Beer Game," a well-known game developed by MIT's Sloan School of Management and played by business administration students and seminar attendees all over the world. It is described in detail in *The Fifth Discipline*.

The premise of the game is as follows:

A song in a new movie popular with young adults and college students mentioned Lover's Beer, a beer made by a small brewery. The few shops that sold this brand of beer noticed an increase in sales shortly after the movie opened. One shop normally maintained twelve cases of Lover's Beer with weekly sales of four cases. The shop's usual order with the distributor was four cases each week. The order would be turned in with the delivery of the new cases of this beer and then processed by the distributor. The delivery of the new order was made

four weeks after the order. In light of the beer's new-found popularity, the shop ordered eight cases of Lover's Beer, double the usual amount.

The second week after the movie opened, the shop sold eight cases of Lover's Beer, leaving only eight on hand. The next week, the usual four cases came in and eight cases were sold. The shop had only four cases on hand and only four cases were coming in next week. They would be out of the beer the next week. Realizing that the movie had a greater impact than first realized, the shop owner ordered sixteen cases that week.

Because all of its shops were increasing the size of their orders, the distributor doubled its order with the brewery. The orders for Lover's Beer kept increasing, so the distributor doubled its order once again. The brewery could double the capacity without new equipment, so in a month it was making twice as much beer as it had previously.

In four months, the brewery, the distributor and the retailer each had more beer than it could sell. Sales went up four cases per week. When the store ran out, it kept doubling its order. The excess inventory stemmed from the fact that no one in the system talked with each other. Instead, order forms did the talking. When the system was disturbed, the disturbance could not be handled and the system broke down.

There are a number of lessons to be gleaned from The Beer Game:

- Structure influences behavior.
  - Systems cause their own crises; they are not produced by external forces.
  - Three sequential players, the retailer, the wholesaler and the brewery ordering a consumable product with a long time delay between order and receipt of the product..
  - Structure causes all players to exaggerate demand.
  - All forces responsible for the disturbance were internal. Demand, an external force, was stable.
- Structure in human systems is subtle.
  - Perceptions lead to decisions or to policies that inform decisions.
  - Lack of delivery had greater impact on order than demand.
- Leverage comes from new ways of thinking.
  - Leverage is a potential that is frequently not exercised.
  - Instabilities could be eliminated, but players fail to recognize the system, only their "job."

Learning Disabilities in the Beer Game

- Each of the players in this scenario only played their position; no one saw the system of interactions or understood how his actions affected other players.
- All of the players blamed each other. This precluded them from learning from the experience as it unfolded.
- Each player's attempt at proactivity—i.e., ordering more beer--only made matters worse.
- Over-ordering and time delays in delivery worsened the problem gradually making it difficult for the players to see the problem until it was too late. A sudden jump in inventory would have provoked questions.

In summary, if we understand structure and how it is intended to work, we can alter behavior in a way that generates desirable system outputs.

System structure —>Patterns of behavior —>Events

.2 Laws of the Fifth Discipline

Senge observed that the actions organizations take to solve problems usually make matters worse. He catalogued many such efforts and called them "Laws of the Fifth Discipline."

1. Today's problems come from yesterday's solutions.
    - Last month's rebate program generated early sales. Now current sales are off.
    - A retailer cuts back inventory to lower overall costs. Customers are upset because they cannot get products when they need them. As a result, they take their business to other retailers.
2. The harder you push, the harder the system pushes back.
    - Success in getting the job done attracts more work and creates higher expectations.
    - Low income housing and job training for inner city inhabitants attract more people to the city. Additional resources are not available to serve the enlarged population, so the program fails to meet goals.
    - Food for developing countries reduces deaths but also results in a larger population. This brings more malnutrition. Local farmers and markets are destroyed by additional UN giveaway programs, making them more dependent on aid.
3. Behavior grows better before it grows worse.
    - A low-leverage intervention produces a natural short-term benefit, followed by a delay, then by disaster.
    - The problem: symptoms are being dealt with, not the root cause of the problem.
    - When sales are down, for example, some companies cut back on research and development. Cutting R&D means cutting the creation of new products, new products that might have generated additional income.
4. The easy way out usually leads back in.
    - We use familiar solutions--what we know best--regardless of the nature of the problem or the system in which it exists.
    - If a sports team does not have good enough athletes, fire the coach.
    - If goals are not met, blame someone else (e.g., employees, the Japanese, old equipment, US workers, etc.)
    - The net result: the problem has not been solved and the time that could have been used for generating and implementing a real solution has been wasted.

5. The cure can be worse than the disease.
    - The long-term, most insidious consequence of applying non-systemic solutions is increased need for more and more of the solution. Short-term solutions lead to long-term dependency. Relief agencies help a host institution, only to leave the system fundamentally weaker than before. Do we give people food or teach them how to produce food? The short-term solution is much easier and quicker than the longer term fundamental solution.

6. Faster is slower.
    - Every system has an optimal rate of change. Trying to go faster is a tremendous drain on resources and has little impact.
    - Everyone tried Total Quality Management and abandoned it.
    - It takes two years to begin to change an organization. Most CEO's cannot wait that long or they do not last that long.

7. Cause and effect are not closely related in time and space.
    - The effects of many actions may not be immediately detectable.
    - The challenge of a new competitor, for example, is not felt quickly. It will take years before the impact is significant. Likewise, an effective response to a problem may not be effective immediately.

8. Small changes can produce big results ─ but the areas of highest leverage are usually the least obvious.
    - Small, well-focused actions can produce significant enduring improvements. This is the principle of "leverage."
    - For example, at a time when personal savings were at an all time low, personal debt was soaring, and the national debt was rising rapidly, there was great concern that there were not sufficient resources to finance needed business expansion. IRA, then 401K tax shelters were created. They increased available capital, reduced consumption and taxes slightly, stalled inflation and allowed the economy to stabilize without crashing.
    - The focus on customer service or product reliability is also leverage.

9. You can have your cake and eat it too, but not at once.
    - You can have a product that is low cost and high quality, but time and effort are required. To figure out how to have both, you must be able to see your organization as a set of systems and processes. Taking a snapshot view of each function independently will not be adequate
    - It takes time, but by eliminating scrap and rework, reducing inspection, increasing Just in Time manufacturing, creating better designs and material, you can achieve lower production costs, lower warranty costs, increased customer loyalty, reduced sales promotion needs, etc.
    - Leverage is improving both—cost and production quality--over time.

- Most organizations have twice the number of mangers required and that causes problems. Also, management frequently come from a finance background and subsequently tend towards isolated snapshot thoughts, not process thinking.
- Leverage: reduce management as fast as the system can assimilate the change.

10. Dividing an elephant in half does not produce two small elephants.

    All of the organization is needed. Parts cannot be separated out and still have a functioning enterprise. Challenging managerial issues requires viewing the system as a whole, not focusing on its isolated parts. Similarly, organizational change must be guided by systems thinking, not through a series of fragmented actions on isolated parts of that system.

    For example, when a firm acquires a new business and abandons old ones it usually delays the firm's problems rather than solving them. While replacing old parts of the system might have short-term positive effects, it typically causes problems downstream. The problem here is the organization's failure to see itself as a complex system, and instead, as a set of isolated businesses.

11. There is no blame.

    Most system's problems are internal. The cure lies in assessing and acting on the relationships among the system's internal parts. Most organizations, both industry and government, rush to attribute blame when a problem occurs. This takes the focus away from where it should be, which is looking at the system as a whole to identify and resolve its problems.

If an organization's systems are not performing as desired, they can be improved by increasing the personal mastery of those who are managing and operating the systems. Positive changes also require changing mental models to adjust expectations. Team learning must be increased to identify and solve problems. Shared vision must be established to give teams accurate goals, and systems thinking must be employed to see how systems interact. In other words, all of the disciplines are required for successful development and implementation of better systems.

A Shift of Mind

There are two types of complexity: detail complexity and dynamic complexity

- Detail complexity: the complexity of many interrelated variables.
- Dynamic complexity: the complexity of cause and effect, where the effects of interventions, over time, are not obvious.

The real leverage in management situations lies in understanding dynamic complexity, not detail complexity. To effectively manage it must be understood that any given action might have dramatically different effects in the short and long terms. To understand and intervene in a dynamically complex system, a manager must use intuitive observations, carefully integrate resources, and identify trends. It also requires seeing change as a process involving complex interrelationships rather than just a linear cause and effect chain. It means remembering that implementing the seemingly obvious solution to a problem does not always produce an obvious or desirable result.

One electrical equipment manufacturer had a small plant in a town of 50,000 people. Corporate headquarters staff members were not satisfied with the labor costs there. They did a cursory study and learned that labor costs in Puerto Rico were less than half that in the existing plant. They had a new plant built there and moved the entire facility. As soon as production started customer complaints came in and did so in substantial numbers. The products were not built according to specifications. The written plans and prints were followed carefully. It was discovered that employees of the former plant made changes that customers requested but never wrote the changes down. The company had to fly several former employees to Puerto Rico for six months to get the products up to date.

The company lost some customers, had unexpected costs and failed to meet profit goals for several years. They did not take into account the knowledge of the employees and their relationship with customers. Headquarters staff looked at the pant as detail complexity. Employee knowledge and customer relations introduce dynamic complexity that was not anticipated.

7.4.2 The Five Core Disciplines

- Personal Mastery
- Mental Models
- Shared Vision
- Team Learning
- Systems Thinking

.1 Personal Mastery

The Spirit of the Learning Organization

The first revelation: the 5th Discipline is almost a religion.

An organization learns through its people; they are the organization's change agents. For an organization to improve, its employees must grow and improve. Personal Mastery recognizes the tie between organizational and personal improvement.

Our traditional hierarchical organizations are not designed to provide for employees' higher order needs ─ self-respect and self-actualization. "Managers must redefine their jobs, must give up planning, organizing and controlling. They must realize the almost sacredness of their responsibility for the lives of so many people" (Senge, 1991, Ch. 9). Yet massive layoffs are destroying the fabric of society. Pension plans are being looted. People are being laid off just prior to retirement to forego pension pay-outs. Such actions show little appreciation of the contribution of employees.

Mastery and Proficiency

Personal Mastery involves approaching life creatively, not reactively. Consider two movements:

1. Continually clarifying what is important to us.
2. Continually learning how to see current reality more clearly.

People with a high level of mastery share several basic characteristics.

- Are motivated by a special purpose that lies beyond their own vision and goals
- Experience their vision as a calling rather than just a good idea
- Assume that current reality is an ally, not the enemy
- Work with forces of change rather than resisting them
- Are committed to continually seeing reality more accurately
- Have the capacity for delayed gratification

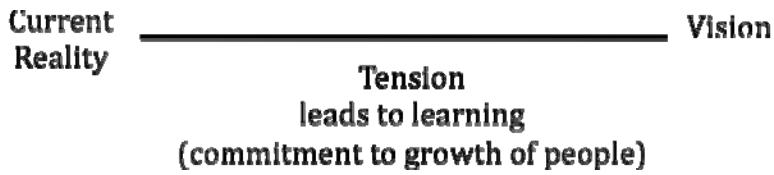

Figure 7- 13 Personal Mastery Model

Personal mastery is the discipline of continually defining the vision and institutionalizing learning so as to facilitate the realization of that vision for yourself and your organization.

Personal Vision

"The ability to focus on ultimate intrinsic goals, not only on secondary goals, is a cornerstone of personal mastery." (Senge) The organization must create an environment where its employees can meet their intrinsic needs through their work. It is that kind of employee that makes the organization productive and competitive. In this way, the organization's vision provides for employees meeting theirs. It is more than simply focusing on what you want it to get rid of (negative vision) or how you might alleviate the symptoms associated with current problems (diminished vision).

Vision is also intrinsic, not merely relative. It is about continually achieving excellence, not only striving to be better than your competitors. It is about aiming for the highest level of customer service, for example, not just being Number One.

All management decisions should be guided by this vision. The vision sets the culture for employees to flourish. If management decisions appear to contradict the organization's vision, the impact ripples negatively throughout the entire organization.

Leveraging Creative Tension

The gap between current reality and vision is called creative tension. It is the central principle of personal mastery, integrating all elements of the management discipline. A wide difference between current reality and vision is an indication of how much work needs to be done, how much learning will be necessary – learning increases personal mastery, may impact mental models, may make you reevaluate the vision, and challenge its value.

Leveraging creative tension requires that an individual or management be honest with himself and with the firm about what the vision is, how it plans to achieve it, and where he or the organization currently stands in relation to it. It is also vital that the decisions made are well

aligned with the vision and are born out of an accurate understanding of current reality. Remember that an accurate understanding of the current situation is equally as important as the vision itself.

For example, a project engineer was expecting a positive customer review of a large project in the middle of the design cycle. The customer was dissatisfied. the customer wanted reliability emphasized where the engineer minimized cost. There was a misunderstanding on the vision. Once that was clarified, the project proceeded to a successful conclusion. The engineer had a clear but erroneous view of current reality. That is why there are mid-course reviews. Both current reality and vision are re-evaluated.

Successful leveraging of creative tension requires regular, frank communication with the organization. The communication should clearly telegraph what the organization's vision is, where the firm currently is in relation to it, and the steps that are necessary to achieve it. Communication of this kind encourages individuals within the organization to accept the vision and drives them towards achieving it.

When current reality is perceived as growing further from the vision, emotional tension increases within the organization, as does the pressure to reduce the goals associated with that vision. Personal mastery means resisting this pressure, and working to understand and implement the actions necessary to bring current reality in line with the vision.

Using the Subconscious, or You Don't Really Need to Figure It All Out

Complexity is best dealt with using the right side of the brain. Most solutions to organizational problems are not arrived at by standard analytical approaches. Students, for example, cannot sit down and write a term project immediately after all data is collected; the subconscious first needs time to assimilate the information, organize the effort, and develop an image of the completed project before it can actually be drafted. When engaged in organizational improvement work, first develop a mental image of the organization as you want it to be. Ask yourself, "What will the organization look like? How will it function?" These images are the product of the subconscious and should be shared with the organization in order to make them a reality. Remember, if you have not *seen* the vision, others will not recognize it either.

Personal Mastery and the Fifth Discipline

- **Integrating Reason and Intuition** Intuition is the creative side of an individual and is used to generate vision. The rational side must be used to test the alternatives generated through this subconscious act.
- **Seeing Our Connectedness to the World** As we grow older, we have a greater tendency to respond in patterns based on experience. We must guard against this and continue to widen our horizons. In Search of Excellence advises that letting lower levels of the organization develop alternatives keeps the whole organization moving.
- **Compassion** We all work within systems, and everything we do within a system has an impact on others and vice versa. The better we see a system, the more compassionate we tend to be because we are better equipped to take account of our impact on others.
- **Commitment to the Whole** The system is larger than we are and will eventually serve the world.

- **Fostering Personal Mastery in an Organization** An organization's culture must encourage personal mastery. It must value growth and create a culture where team members feel safe to create and share their visions. The culture must also offer members of the organization a systemic view of the organization, as well as an understanding of how it relates to its environment.

.2 Mental Models

Why the Best Ideas Fail

New insights fail to get put into practice because they conflict with deeply held internal images of how the world works. These internal images are called mental models. People do not always conform to their espoused theories, but they *do* conform to their mental models, This is potentially problematic, as most mental models are inaccurate and/or incomplete. For example, US automakers have been guided by a mental model that assumes US car buyers are much more concerned about style than performance and economy. This incorrect assumption ultimately hurt sales of US autos in the US market.

By becoming aware of these models in yourself, you can ultimately predict--and potentially change—your behavior as it relates to them. This is vital for the effectiveness of the Fifth Discipline. If one wants to think systematically, he must be aware of how his mental models potentially predispose him against systems thinking. Awareness of one's mental models is also vital for learning. Without such awareness, his capacity for learning is often impeded, as is his ability to effectively understand and improve the functioning of his organization.

Business Worldview

Shell Oil determined the most likely oil supply scenarios. When OPEC would shut off the oil, Shell had a plan. The problem was their managers did not believe in the possibility. The scenario went against their mental model.

Shell recognized the problem and managed to break those models so that when the oil was shut off, they decentralized control to allow for maximum flexibility. Their competitors did the opposite.

Skills

Problems with mental models include what Senge calls leaps of abstraction. This is where one or two facts fit with a preconceived notion and becomes the basis of a bad decision.

Recognizing leaps of abstraction.

- Two data points allow a generalization.
- Two workers loafing ─ no one wants to work anymore. Two data points - two workers not working - allow evidence for a preconceived bias. All must be aware of the problems that this causes.

Balancing inquiry and advocacy. Ask questions to learn, then take a stand. The organization should encourage understanding prior to decisions. Institutionalize inquiry so that people will know what to expect. It isn't persecution; learn to provide data.

Face the distinctions between espoused theory and theories in use; what we say vs. what we do.

Prescriptions for Improvement: Internal Boards

A manager learning to work with a group is more effective than a manager attempting to communicate with her team members one-on-one. More checks of mental models (assumptions) are made when the group works in concert. Some organizations have internal boards of recognized experts who are available to a wide range of employees. The expert board can meet together to help the organization define positions on new ideas. If a subordinate is right about a matter, a board can help convince a boss and grand boss. Forward thinking organizations require managers to develop alternate scenarios and plans of action for each decision. It gets the manager out of the rut of assuming one future possibility.

.3 Shared Vision

A shared vision, especially one that is intrinsic, uplifts employees' and customers' aspirations. It helps members of the organization to answer the question "What does the organization want to create?" The shared vision must be a force of impressive power. As such, it will foster experimentation and risk-taking, as well as provide the organization with long-term focus. It is also vital to creating a culture of learning.

Remember, an organization goal limited to defeating an opponent or competitor is only transitory and can easily slip into a defensive posture. It is much smaller than a shared vision, and unable to sustain a company's long-term success.

Discipline of Building Shared Vision

The only vision that motivates you is your own. It is, therefore, key that the organization encourages the development of personal vision and personal mastery, as these are the basis for building a shared vision. When members of an organization develop, the organization is capable of building a shared vision that inspires further personal as well as organizational growth.

Personal to Shared Vision.

Vision is too frequently developed by top management and a consultant and then fed to the organization in a uni-directional, top-down fashion. To be successful, however, leaders must continually share the vision. They must allow others to commit to it and even expand it, continuously.

Depending on how the vision is shared, team members might accept or reject it in a variety of ways:

- Commitment ─ Will make the vision happen. Creates whatever "laws" are needed to enact the vision.
- Enrollment ─ Wants to see the vision achieved. Does what is expected within the spirit of the "law."
- Compliance ─ Genuinely sees the benefit of the vision and does what is expected and potentially more. There are two modes of compliance:

  - Formal: Does what is expected
  - Grudging: Does what he can get by with
- Noncompliance ─ Against the vision
- Apathy ─ Does not care one way or the other

Committed people perform miraculous tasks. The team that developed the McIntosh computer, for example, signed the reverse side of the computer case where no one would see them as a sign of their solidarity and as an indication that the company valued the accomplishments of every team member.

For "converting" weak supporters of the vision, as well as those who are non-compliant and apathetic, there must a developed, well thought-out plan. In doing so, remember that many people have never been asked to commit to anything, so approach the issue deliberately. A critical mass of committed employees is necessary to establish the vision.

For the remainder of the discussion of personal vision and mastery, it is important to understand the meaning of the following terms:

- Vision ─ picture of the future the organization and its members seek to create.
- Mission ─ is the reason the organization exists.
- Values: How the organization acts, consistent within the mission to achieve the vision.

Why Visions Die Prematurely

Visions spread when reinforced through clarity, enthusiasm, communication and commitment. That said, a number of factors might cause a vision to die prematurely:

- Too many diverse views are in play; focus dissipates and unmanageable conflicts arise.
- People are overwhelmed by the demands of their current reality and lose focus on the vision.
- Employees are too busy today to focus on tomorrow.
- The vision is not continually and enthusiastically shared, so people lose their zeal for their vision and forget their connection to one another.

.4 Team Learning

There are three critical dimensions to team learning:

- Thinking insightfully about complex issues, such as the impact a decision has on the global economy. Here teams must learn how to tap the potential of many minds over the one.
- Innovative, coordinated action. To have an impact, many must act together in concert. A division of labor combats and/or inhibits such attempts.
- Learning must happen throughout the organization. Since most implementations are done through and by multiple teams, all involved must understand how their actions/function impacts others. The role of Likert's Linking Pin (discussed in Domains 3 and 7) is vital in this respect.

Prototypes

Prototypes are recurring situations that use a combination of disciplines in an approach to solve problems or deal with major issues.

7.4.3 Openness and Localness

Openness

Most members of the work force are interested in something more than just internal politics. They want to feel like their work contributes to a larger purpose, whether that's the advancement of the organization's agenda, or that of their community or family. In other words, individuals frequently want their own personal vision to align with a larger, organizational goal

Effective management facilitates this alignment by fostering a culture of reflective openness. In such a culture, management is willing to hear and consider the validity of an individual's thoughts on its managerial decisions. This is more than simply giving employees a forum for speaking their mind (although this is a useful start) and also different from making decisions via group consensus (this is not a particularly practical way to run an organization). Rather, reflective openness requires that managers create a culture where employees feel free to comment on managerial decisions and can expect that such comments will be given their due consideration.

This is especially important in large organizations where top management is far removed from the front lines of production. In these types of organizations, it is frequently the men and women closest to production who have the best sense of what's broken and how to repair it. Without a culture of reflective openness in place, employees are less likely to share their insights and recommendations with management. This would be a true loss for the organization.

Localness

In hierarchical organizations, executive management does the *thinking*, while local employees *act*. In most organizations, however, this centralized model no longer suffices. Those closest to a situation must be able to both think *and* act. To meet these demands, effective organizations implement a decentralized form of management known as local control.

In order to implement effective local control, the organization must be dedicated to team learning, quality thinking and reflection. It must develop and disseminate a shared vision and implement mental models that ensure complex business issues are understood at all levels. It is also important that learning be conducted within the context of actual responsibilities. When people's fate lies in their own hands, learning matters.

While the need for local control might be obvious, few managers actually implement it. Many, for example, are too invested in remaining "in control" themselves. Others claim to have tried local control, only to find that local team members are not good decision makers. These assessments, however, are frequently premature, i.e., they are made before local managers have actually had enough time to obtain the experience necessary to become good decision makers.

Similarly, if management merely institutes local control as a short-term response to a change in the competitive environment or as a temporary means for cutting costs, it is not likely to last when conditions improve. To truly hold, local control must be instituted as one of the organization's core values. This is the case at Johnson and Johnson (J&J), for example, where over two hundred local divisions regularly make their own decisions.

Sometimes, more ambiguous situations are pushed down for solution while top managers retain those issues which are more clear-cut. This inverts the intended effect.

The New Role of Central Management.

Within the context of local control, central management's key function is to design the organization and allow local management to run it.

Forgiveness

Good managers inevitably make mistakes, and within a learning organization, these mistakes must be seized as learning opportunities. Those who make them should be foregiven. As a J&J CEO once pointed out, "If you are not making mistakes, you are not making decisions and taking risks. We won't grow if you don't take risks." [176]

A MANAGER'S TIME

According to Senge, most organizations assume that a manager's success is directly proportionate to the amount of time she spends in motion. Incisive action, however, must not be confused with incessant action. To be truly effective, a manager should also be spending time reflecting and analyzing. As one of the organization's experts, she should be continuously developing hypotheses, acting, and then pausing to reflect on results. It is only in this cycle of action and reflection that she can attain personal mastery and success. Otherwise, neither she nor the organization will be able to learn from past mistakes.

Similarly, most organizations require that their top managers make too many decisions. A top manager's time, however, should be reserved for complex decisions that relate to the organization's direction and future. As Bill O'Brien, former CEO of Hanford Insurance Company said, "It's a big year if I make 12 decisions."[177] It's the organization's lower levels of management who should be responsible for less complex decisions or those without significant organizational impact.

MICROWORLDS

Computer simulations of business activities are a useful way for management to develop effective strategy. Using simulation software, managers may test a variety of approaches to any given business scenario or problem, gauge the results of each, then select the best alternative. They can then disseminate that solution to key managers throughout the organization.

---

[176] Peter Senge, *The Fifth Discipline Field Book Strategies and Tools For Building a Learning Organization*, New York, NY, 1994, p 300.
[177] ibid, p. 304.

The Leader's New Work

To transform a company or practice into a learning organization, its leader must possess the following traits.

- The Leader as Designer

  As a successful organization expands, managers with a diverse range of backgrounds and experiences are brought in, potentially diluting the organization's vision and values. It is the leader's job to make sure that new managers are quickly and efficiently assimilated into the organization in such a way that it maintains its vision, values and mission.

- Leader as a Steward

  The purpose story is the organization's "big picture" story. It describes how and why the organization functions, including the value it creates for its community and for society in general. It is through this story that employees can positively relate to the organization. It is the leader's responsibility to tell this story and make sure that it is effectively disseminated throughout the organization at all levels. The rate at which organizations learn and live the story is its only true competitive advantage in a knowledge intensive business.

- Leader as Teacher

  The leader influences events, patterns of behavior, systemic structures and the purpose story. The continual retelling of these purpose stories is a key leadership function, as it gives people a positive sense of the organization's value. It is rare that you will find a successful organization that does not have a positive purpose story.

How Can Such Leaders Be Developed?

Good leaders continually work at honing their leadership skills. They include the following characteristics:

- Clarity and persuasiveness of their ideas
- Deep level of commitment
- Openness to continual learning

A charismatic leader without these qualities, is charasmatic without substance. It is the combination of charisma and leadership skills that makes for a strong leader.

7.4.4 Archetypes

Nature's Template

Recurring patterns of structure are called Archetypes. We are held prisoner to these archetypes if we lack awareness of them. Some of the most prevalent of these archetypes are discussed below.

Archetype 1: Limits to Growth

Organizational growth is frequently limited by management's failure to add resources in areas that require them. Systems thinking enables leaders to identify these growth limits and make the necessary resource adjustments. For example, a talented engineer started a consulting company. He initially did all the work himself: developed bids, did the technical work, answered the phone, sent out invoices, paid the bills, etc. The business grew, so the owner hired another engineer. Meanwhile, the owner continued to do the administrative work as well as the primary technical work. Eventually, he was overloaded and getting behind in paying suppliers and bidding for future jobs. His solution to the problem was to work harder. As the jobs got further behind and paper work further backed up, the owner finally hired an administrator. Within a month the paper work was in order, bills were paid, and bids were prepared for new jobs. The lack of an administrator was the limit to the firm's growth.

When we experience a slowing of growth, our first strategy is typically to try harder. The more successful approach, however, is not to push growth, but to identify and remove the factors that are limiting it. It is important to remember that with every growth effort, there is a usually a system acting to opposition it. Leverage lies in identifying that system and making the necessary changes. The primary reason Quality Circles, Total Quality Management, and Just In Time inventory systems quickly stagnated or failed after grand beginnings, for instance, was because management was rarely able to identify and remove the structures and systems that were prohibiting their growth.

Archetype 2. Shifting the Burden

When a manager is unwilling to attack a problem at its root because doing so is too difficult or costly, and instead opts only to alleviate the problem's symptoms, he or she has shifted the burden. Doing so might have short-term benefits, but these are usually far outweighed by the ongoing negative impact of the unresolved problem. Taking this symptomatic approach also distracts resources from resolving the main problem and perhaps missing a critical opportunity.

As an example, a U.S. business is losing domestic business to a foreign competitor who is able to offer a better quality product at a lower price. The U.S. company considers the following options:

1. Lobbying for higher tariffs
2. Cutting costs by laying off workers
3. Increasing quality and productivity

If the company shifts the burden and opts for 1 or 2, then 3, the option most likely to address the root problem, will become much more difficult to implement. Laying off workers, for example, might generate labor unrest, including a strike. But even if labor problems were not an issue, option 3 is still likely to be the most challenging, but the one most likely to improve the company's long-term prospects.

In order to avoid shifting the burden, leverage lies in the following principles:

1. Strengthen the fundamental response. Identify and face the problem.
2. Weaken the symptomatic response. Resist the temptation.

The first principle requires an organizational culture that encourages a shared long-term vision. The second principle requires leaders who are willing to expose short-term solutions as frauds.

Archetype 3: Growth and Underinvestment.

The time to invest in capacity is before you need it, not after. If the need for capacity already exists, you risk the cost of losing sales, and the potentially higher cost involved with producing more product than the system has the capacity for. You also risk problems with quality.

It is easiest to blame a failure to invest on some external force, such as the competition, new regulations or the union, but most problems are internal. Leverage is in small, focused actions that have the greatest positive influence on the system. You don't have to do everything, just the right things.

Expenditures in capacity are likely to be an investment that generates returns. The lesson here is to build capacities in advance. Hold to values. Invest in capacities most related to success. Leverage Capacity.

7.4.6 Identifying Management Systems Applicable to Tech Driven Organizations

Is Anything Missing?

In addition to improving existing systems and identifying systems that are counter-productive to the organization's mission, it is also important to consider which systems put your organization at a disadvantage if they are absent.

Is there a system that promotes innovation?

Every organization wants innovation, but if there are not systems that encourage it, it will not happen. Johnson and Johnson, for example, has several ways that an employee with a new idea for a new product can get funding to try it out. 3M mandates that each professional employee spends 15% of his or her time working on ideas for which there are no assigned charge numbers.

Is there a system that tracks developments by competitors and research and development in allied industries.

It is easy to become so preoccupied by internal activities that external developments are not adequately tracked. One manufacturer was having difficulty making enough material for prompt delivery to customers. They were losing orders to competitors who could deliver faster even though those competitors charged more for a similar material. The manufacturer countered by having employees work massive overtime to fill a warehouse with material so that shipments could be made almost as the sales were made.

As soon as the warehouse was filled, it was learned that a major competitor had developed new material that was 20% stronger and 10% cheaper than that in the warehouse. Millions of dollars of inferior product that was not salable was in the warehouse. The manufacturer's

own research and development was under-funded and out of touch with industry developments.

Is there a system that reward's creative and productive employees?

Many compensation systems were designed for organizations with many employees doing similar tasks and contributing similar value. These systems are not adequate to industries employing highly skilled knowledge workers. For those industries, the compensation model should explicitly acknowledge the outstanding contributions made by inventors, process developers, innovators, system designers, etc. This approach is better suited for recognizing knowledge workers and encouraging them to continue contributing value to your organization.

Summary

The Systems block of the integrated management model requires that the organization be recognized as a large system made up of many interrelated systems. It forces the engineering manager to view the organization as a whole and not its parts. Systems Thinking is an intuitive process where we are required to "connect the dots" to understand complex situations and to make appropriate decisions. The management of an organization must see that the organization provides opportunity for employees to develop and meet individual goals.

This places a significant responsibility on the engineering manager but also a significant opportunity to make an organization that allows its employees to do their best.

7.5 Leadership

Effective organizational leadership sets the tone for the organization's culture and establishes it as people-oriented. It drives the selection of organizational structure and the choice of management systems, as well as deploys the resources of the internal environment to meet the needs of the external environment.

7.5.1 Management vs. Leadership

It would be a mistake to assume that leadership is the same as management. The two are, in fact, significantly different modalities.

Management involves:

- Dividing scarce resources to meet organizational needs
- Organizing and scheduling activities
- Being mission oriented
- Coordinating the work system with the support system
- Focusing on yesterday, today and tomorrow

Leadership, on the other hand, involves:

- Establishing the vision for what the organization strives to be

- Setting the values of the organization and living by them
- Motivating the organization through opportunity and empowerment
- Focusing on the future
- Giving credit where credit is due
- Allowing the lower levels of the organization to make significant contributions and decisions

Leadership is a necessary ingredient for a productive organization to sustain itself. Management by control alone is not sufficient. Imparting a shared vision of the organization's goals generates the necessary communication throughout the organization and motivates team members to achieve. In fact, intensive communication and shared vision are the most potent of control systems and are in large part the products of leadership.

Without effective leadership, an organization misses out on significant untapped potential. Consider, for instance, the following statistics:

- Fewer than one of every four job holders say that they are working at full potential
- One half say they do not put effort into their job over and above what is required to hold onto it
- The overwhelming majority, 75%, said that they could be significantly more effective than they presently are
- Close to six out of ten Americans on the job believe that they "work as hard as they used to"

Leadership is the function that bridges the delta between a team member's capacity to do something and his or her willingness to actually do it. By sharing a vision of what the organization can accomplish, by opening the lines of communication to empower employees, and by demonstrating the interconnectedness of systems to all levels of the organization, team members are far more likely to perform at their full potential.

Strategies for Effective Leadership

In their work on leadership, Warren Bennis and Burt Nanus outline the following strategies for effective leadership:[178]

1. **Establish Vision**. In order to create a productive organization, leadership should first establish clear goals in the form of a vision. That vision should encapsulate the best the organization is capable of becoming, and should be good/strong enough to pull team members towards it.
2. **Communicate the Vision**. Leaders should communicate the vision to every level of the organization and be sure to translate it into terms that are understandable to each of those levels. If the vision is effectively communicated throughout the organization, and is believed by a majority of its members, the vision will be accomplished.

[178] Bennis, Warren and Nanus, Burt, *Leadership, The Strategies for Taking Charge*, Harper Collins, New York, 1985.

3. **Remain Determined and Promote Trust**. Keep at the vision and trust that your employees will deliver. Promote trust among the organization's various levels and teams; help each to see that the others are doing their best to achieve the vision.
4. **Have A Positive Self Regard**. You must believe in yourself and your ability to work with and change the organization in line with the vision. The Leader is the catalyst for establishing the vision and sustains it through constant promotion.

Leadership - Effectiveness Theories

One school of leadership thought, the European school, holds that leadership is a trait that one is born with. It is not a skill that can be taught or learned.

The Harvard Business School relies on case studies as a critical part of teaching. The reliance on case studies suggests that leadership is at least partially based on experience, even if it is someone else's as in a case. It also suggests that leadership can be taught.

Others say that leaders possess certain traits that make them effective. Trait theories are the first discussed below.

Trait theories: intelligence, extrovert personality, social background, etc. have been suggested as traits that enable leadership. Results of research, however, are inconclusive. One's supervisory ability had the most significant correlation.

Leadership Style has also been studied. A survey instrument was developed to measure leadership. It was the Leader-Behavior Description Questionnaire (LBDQ). It tested four factors.

- Leader Consideration - concern for people.
- Initiating Structure - self starter.
- Production Emphasis.
- Sensitivity

Only the first two together had a significant correlation with one's ability to be an effective leadership.

7.5.2 The Covey Approach: The 7 Habits of Highly Effective People

The 7 Habits of Highly Effective People by Stephen Covey takes a more practical approach to leadership.[179] He developed seven leadership habits from research, observation and experience. They are as follows.

1. **Be proactive.** Actively cause things to happen instead of merely reacting to situations that are "beyond your control." When management reacts, it seeks to return to or sustain the status quo. While appealing--and almost comforting—reacting prohibits progress. Being proactive, on the other hand, allows each member of the organization to look for opportunities to move toward the vision.

[179] Covey, Steven R., *The 7 Habits of Highly Effective People*, Simon and Schuster, New York, 1989.

2. **Begin with the end in mind.** Like great golfers lining up a shot, leaders visualize where they want their organization to ultimately end up, and *then* decide the steps or actions necessary to get there. They must be able to do this amidst the business of day-to-day business activity, as frequently in the wake of conflicting business intelligence, forecasts, research, etc. It is the leaders function to stick to the vision and keep the organization on the right track.
3. **Put first things first.** Organize and execute priorities based on the organization's goals and values. Covey suggests that leaders learn the difference between Urgent and Not Urgent activities and between Important and Not Important activities. A leader's responsibility is to help identify which activities are Important, then ensure that the organization is prioritizing them. She should also make sure that Urgent activities are dealt with as they arise. This is doing the right things first, as opposed to simply doing things right.
4. **Think win/win, or no deal.** The win-lose model of athletics and politics does not help an organization achieve significant, long-term goals. The only organizational decisions that last are the ones that all parties want to work. The emphasis must be on making major decisions as the result of analysis, discussion and consensus. As with traditional Japanese management, major decisions should be agreed to be all key parties, and when no agreement can be made, then more study is required. All sides must be convinced about and understand the decision. While this may not always be practical, a culture of trust and respect allows difficult decisions to be made.
5. **Seek first to understand, then to be understood. Do not prescribe before you diagnose.** There is a strong temptation to prescribe before we understand, to make the assumption that a situation is similar to one we have experienced. There may be little evidence to support this assumption. Effective listening and observation help us avoid doing this. It is a necessary step in the identification and solution of a problem. After one understands this, he or she has information worth listening to and is more likely to be understood.
6. **Synergize.** Synergy is what happens when all of the organization's principles are working at the same time for a mutually-recognized common good. Trust, confidence and mutual respect are present and enable the organization to be much more than its members believed was possible. Contributions are welcomed from all levels. High performance teams can accomplish much more than its members working independently.
7. **Sharpen the saw.** Personal renewal based on exercising the mental, physical, social/emotional and spiritual aspects of your life is vital to effective leadership. Remember, renewal is a continuous cycle, not a one-time event.

These principles form a useful start for understanding leadership.

7.5.3 The Kouzes and Posner Transformational Leadership Approach

Kouzes and Posner took a radical new approach to leadership in their work *The Leadership Challenge.*[180] They proposed five categories of leadership skills:

[180] Kouzes, James M. and Posner, Barry Z., *The Leadership Challenge*, Jossey and Bass, 2002.

- **Challenging the Process**

  The leader searches out opportunities to change, challenge, grow, innovate and improve organizational processes. Every employee is expected to do the same. Similarly, leaders encourage management and staff to experiment, take risks and learn from any resulting mistakes.

  Many researchers have concluded that the best companies encourage experimentation. Johnson and Johnson, for example, has been successful with its dedication to experimentation. Each year, new products—i.e., those achieved through experimentation--account for 20% of overall sales.

- **Inspiring a Shared Vision**

  The leader commits to envisioning an uplifting and ennobling future. This Vision must enlist organization members by appealing to their values, interests, hopes and dreams. This is frequently neglected part of leadership, as many "leaders" tend to focus on financial matters and, thus, neglect the potential of a motivated work force.

- **Enabling Others to Act**

  The leader fosters collaboration by promoting cooperative goals and building trust. The leader strengthens by giving power away, providing choice, developing competence, assigning critical tasks and offering visible support.

  Much of an organization's success comes from the efforts of team members doing work in its lower levels. Enabling those members unleashes their true capabilities, and by extension, unleashes the organization's full potential.

- **Modeling the Way**

  The leader must set the example by behaving in ways that are consistent with shared values. Setting good examples creates a positive control system that people understand and conform to.

- **Encouraging the Heart**

  Leaders must regularly acknowledge and celebrate individual and team contributions to an organization's success. This is a key characteristic of any excellent organization.

  These five leadership skills put the people emphasis of management into clear focus. This people orientation ties leadership back to the people block of Westbrook's management model in Figure 7-1 above. Note: these five categories are not mutually exclusive; each is closely related to the others and rarely occurs in isolation.

7.5.4 Proactive Leadership

Leadership must be involved in all phases of the organization. The current emphasis is on financial affairs. This is an important aspect but it is the result of the functioning of the organization. Finance cannot be managed. It is the result of managing. It is the result of the use of people getting the job done. It is a result of having the required facilities and equipment to compete in the global market place. It is the result of effective planning to have

the right products and services available when they are needed. Proactive Leadership works with talented people to get these things done. Good finances follow.

7.5.5 Leadership Succession Planning

The mark of an effective leader is the recognition that he or she will not be in that position forever. As a result, he or she should formulate a succession plan. The plan should include the methodology for selecting a successor, and specify whether the candidates should come from inside or outside the organization. Note: Small organizations may not have the luxury of promoting an in-house candidate.

If in-house candidates do exist, it is necessary that each person is given the opportunity to develop and demonstrate his or her capabilities prior to taking the leadership position. It may be possible to agree on the successor a few years from the leader's retirement. This is despite the fact that no one ever knows when succession will happen.

The Plan

An executive committee must, with input from all levels of the organization, develop a succession plan. In this way, everyone is familiar with the process and will not panic when the plan is implemented. Uncertainty is a formidable enemy that causes the resignation of valued employees, in-fighting among existing staff, and failing productivity.. The plan must allay those fears of the unknown.

Plan Functions

- Names an Interim leader
- Establishes the requirements for the job, as well as necessary attributes.
- Names a selection committee responsible for screening applicants and developing a "short list"
- Identifies a Committee Chair responsible for communication with the organization.
- Establishes the protocol for the interview process
- Identifies the time frame for the search.

Summary

Leadership is a much sought after commodity. It is not something one is born with, nor is it a set of traits that can be learned. Leadership is a discipline, derived from skill and experience. Successful organizations require effective leaders to do more than just manage; they must inspire.

Senge and Kouzes and Posner provide valuable lessons for leaders. Senge refers to the discipline and habits of leadership. Kouzes and Posner emphasize that leadership is about inspiring, enabling, modeling and encouraging people while continually challenging the process.

Most importantly, leadership is about people.

7.6 Human Resources Management

7.6.1 Recruitment, Selection, and Compensation Practices

Futurists predict that by 2010 there will be more jobs than people to fill them. As the unemployment rate drops due to retirements and population shifts it will become progressively more difficult to recruit choice candidates to fill vacant positions and to expand business operations. It is believed that this phenomenon will drive up employee compensation demands. As competition for qualified applicants increases, companies will need to search out new ways to recruit and retain top performers.

.1 Knowledge of Corporate Resources for Company Recruitment and Selection Policies and Practices

Employers have traditionally used the published job market to drive employee recruitment efforts. They advertise job openings on the company website, in major newspapers and in trade magazines. They post openings on Internet job boards and enlist the aid of professional recruiters known as head hunters to seek the right person for the job. Many companies participate in job fairs and sponsor large scale recruiting efforts on college campuses. As the number of job seekers decreases, employers have begun to make use of non-traditional recruitment methods, such as those listed below.

- **Capitalizing on the networks and professional contacts of existing employees:** Many companies offer incentives to existing workers who can influence their colleagues to apply with the company. Employees are encouraged to seek out alumni from their colleges and to use networking events to help recruit qualified candidates.

- **Referrals from job applicants and past employees:** Most job applicants know others who are also applying for jobs and can be a good source of referrals. Former employees should also be contacted when openings arise to ask if they know someone who would be a good fit with the position.

- **Use breaking news:** Watching industry news or national news will inform a company about a competitor's plans to downsize or a top executive's decision to retire.

- **Confer with industry leaders:** Industry leaders often know when relocations, mergers, or acquisitions are about to occur before they are publicized.

- **Sign-on bonuses:** Sign-on bonuses are used to lure employees away from their existing positions and encourage retention after sign-on by requiring the new employee to stay a designated period of time to earn the full bonus.

Putting It Into Practice: Which of these strategies is your company currently using to recruit great employees? How can you add to your recruiting efforts to reach an optimum number of qualified applicants?

Selection Policies and Practices

Historically, selection policies have been geared as much towards weeding out undesirable candidates for employment as towards seeking out the best candidate for the job. Resume

keyword searches can eliminate a large number of applicants without ever speaking to job seekers, and might inadvertently screen out excellent candidates with non-traditional experience or education. Wholesale elimination of candidates is losing its appeal as the labor pool shrinks. Instead, employers are using a multiple interview process to select candidates for hire.

Multiple interviewing is a selection process that requires five or more interviews with a candidate for employment. The process often starts with conducting a group interview with a number of potential candidates. Prime candidates are identified by their interview responses and conduct to continue on with the process. The next step includes comprehensive testing of prime candidates to determine depth of experience, work ethic, personal traits, aptitudes, and attitudes. Those who make the cut then interview with a variety of people within the company, including team members, managers, and people from other departments who interface with the position being filled. The process concludes with try-out employment, which involves the candidate spending several days working for the company before a formal offer of employment is made.

In addition to the multiple interview process, employers also have the option of investigating potential candidates. Reference checks, criminal checks, credit checks, and drug testing are used routinely to screen out undesirable candidates.

.2 Knowledge of Corporate Resources for Compensation Policies and Practices

The shrinking pool of qualified workers has caused concerns on two fronts. Employers are not only making a larger investment in employee selection, but are enhancing employee retention efforts as well. As the cost of employee turnover rises employers are looking at creative methods to ensure that their top performers stay with the organization.

The compensation package is a primary means of attracting and keeping great employees. Ensuring that salaries are competitive is no longer enough, although offering salary ranges slightly above that of your competitors in the region remains a good drawing card for attracting and keeping employees. Pay-for-performance plans, pay-for-results schemes, profit-related accomplishment, stock options, profit-sharing, benefits, and non-monetary compensation are used as additional incentives.

Benefits and non-monetary compensation are no longer limited to time off, medical insurance, and a retirement plan, although these are still popular offerings that influence employee retention. Below is a list of benefits that employers are implementing across the globe.[181]

[181] R. Herman and J. Gioia, *How to Become an Employer of Choice,* Oakhill Press, Winchester, VA, 2000.

- Domestic partner benefits
- Electronic bill pay
- Life insurance
- Pet insurance
- Scheduled annual physicals
- Corporate fitness center
- Nutritious snacks
- Employee barter program
- Child, pet and dependent care
- Supplement public transportation costs
- Direct deposit of paychecks
- Hospitalization and major medical
- Dental and vision insurance
- Adoption support
- Wellness programs
- Subsidized health club dues
- Discount club memberships
- Tickets to community events
- Longer time off
- Trailing spouse care

There are a number of actions that can be taken to ensure that your compensation package is attractive to current and potential employees.

- **Research competitive pay rates in your area annually:** Governmental agencies, chambers of commerce and trade groups are good sources of wage information.

- **Poll current workers:** Ask current employees what they need. Describe a number of benefit options and ask them to select the most desired from the list. Select the most popular item to institute. Make sure your offerings suit the demographic composition of the workforce. Older workers value prescription plans and accelerated retirement plans. Younger employees may be more attracted to take home meals from the company cafeterias so they can spend more time with their families. Repeat this process as often as is economically feasible to do so.

Putting It Into Practice: Which of the benefits listed will the employees in your company value the most?

- **Add benefits based on corporate values:** Add benefits based on the stated values of the organization. If you wish to be viewed as a community benefactor sponsor giveaways of tickets to community events or attractions. If you advertise yourself as having "family values" consider providing or subsidizing daycare and eldercare.

Putting It Into Practice: Which of the benefits listed fit best with the values of your company? How do you determine benefits do your employees find most rewarding? What can you do to help staff capture the benefits they desire?

.3 Basic Knowledge of Federal, State, and EEOC Fair Selection Regulations

Generally speaking, fair selection laws are set by the federal government and further defined and expanded by state law. In California for example, the Americans with Disabilities Act (ADA) has been supplemented by state law to include smaller businesses and more broadly defines the act by expanding definitions and considering a more extensive range of disabilities. Employers need to research the state laws and ensure that they are following the state specific interpretation of all federal employment laws. These regulations can usually be found on state government websites.

The following federal laws prohibit discrimination in selection and hiring practices.[182]

- **The Age Discrimination in Employment Act of 1967 (ADEA)** protects individuals who are 40 years of age or older from employment discrimination based on age. The ADEA's protections apply to both employees and job applicants. Under the ADEA, it is unlawful to discriminate against people because of their age with respect to any term, condition or privilege of employment including, but not limited to, hiring, firing, promotion, layoff, compensation, benefits, job assignments, and training.

- **Americans with Disabilities Act of 1990 (ADA)** prohibits private employers, state and local governments, employment agencies, and labor unions from discriminating against qualified individuals with disabilities in job application procedures, hiring, firing, advancement, compensation, job training, and other terms, conditions and privileges of employment.

- **Equal Pay Act of 1963 (EPA)** requires that men and women be given equal pay for equal work in the same establishment. Jobs need not be identical, but they must be substantially equal. It is job content, not job title that determines whether jobs are substantially equal.

- **The Pregnancy Discrimination Act** is an amendment to Title VII of the Civil Rights Act of 1964. Discrimination on the basis of pregnancy, childbirth or related medical conditions constitutes unlawful sex discrimination under Title VII, which covers employers with 15 or more employees, including state and local governments. Title VII also applies to employment agencies and to labor organizations, as well as to the federal government. Women who are pregnant or affected by related conditions must be treated in the same manner as other applicants or employees with similar abilities or limitations.

- **Title VII of the Civil Rights Act of 1964** protects individuals against employment discrimination on the bases of race and color, as well as national origin, sex, and religion. Title VII applies to employers with 15 or more employees, including state and local governments. It is unlawful to discriminate against employees or applicants for employment because of their race or color in regard to hiring, termination, promotion, compensation, job training or any other term, condition or privilege of employment.

- **Sexual harassment** is a form of sex discrimination that violates Title VII of the Civil Rights Act of 1964. Title VII applies to employers with 15 or more employees, including state and local governments. It also applies to employment agencies and to labor organizations, as well as to the federal government. Unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature constitute sexual harassment when this conduct explicitly or implicitly affects an individual's employment, unreasonably interferes with an individual's work performance, or creates an intimidating, hostile, or offensive work environment.

Putting It Into Practice: What steps have you taken in your organization to prevent discrimination? What else might you do to prevent future claims of discrimination?

[182] Equal Employment Opportunity Commission (EEOC). Available at http://www.eeoc.gov.

.4 Defining Selection Criteria

Federal Government Uniform Guidelines for Employee Selection Criteria require that all standards used either as minimum qualifications or as selection criteria be applied uniformly to all applicants. Minimum qualifications and selection criteria must be:

- Job related
- Measurable and/or demonstrable
- Necessary to perform the work

The development of good selection criteria is a useful technique for outlining the particular needs of a department for the particular position. This process will make the selection much more straightforward and less subjective.

Job Relatedness

All qualifications used to screen applicants in the hiring process must be directly related to the job being filled. If, for example, there is a requirement for a bachelor's degree, that standard must be shown to be directly related to the position. A candidate with a Ph.D. (in a field not directly related to the position being filled) would not be more qualified than an applicant with a B.A. in a related field. If specific knowledge of budget procedures is given as a requirement, the position must require the application or use of that knowledge. Job relatedness means that every standard must be specifically connected to the work to be performed on the job.

Measurability/Demonstrability

Minimum qualifications and selection criteria must be measurable and demonstrable. That means that they can be measured objectively or clearly demonstrated by the applicant or the applicant's past history. If a selection criterion calls for "maturity" or "attitude," there might be many interpretations of what those standards mean. Therefore it would be very difficult to measure the applicant against those vague criteria. A standard such as, "Demonstrated ability to work effectively with supervisors, peers and subordinates," would much more closely fit the requirement of measurability and demonstrability. Demonstration of this ability could be verified through references, letters of recommendation and checks with previous employers. Even a criterion such as "good typist" is not as easily measured as "ability to type 60 words per minute with only three errors." The more specific the criterion, the more easily it can usually be measured or demonstrated.

Necessary to Perform the Work Successfully

All criteria listed as minimum qualifications or selection criteria must be necessary to perform the work successfully. If a bachelor's degree is given as a requirement for the job, but it cannot be demonstrated that the actual degree is necessary for the performance of the job, then a criterion like "bachelor's degree or equivalent" must be used instead. Relevance and quality of education may be considered in the selection process but must be shown to be necessary for the particular job.

When to Use Federal Guidelines

Every time a description of qualifications and criteria for a job are developed and recorded on posting notices, advertisements, and personnel forms, all three of the federal requirements explained above must be met, both for minimum qualifications and for selection criteria. No standard may be used which might have the effect of illegally excluding protected groups either intentionally or unintentionally. In meeting these three requirements, it is essential that a careful and thorough assessment be made of the responsibilities of the position. The assessment should include:

- Understanding the precise responsibilities of the job
- Defining those responsibilities in measurable or demonstrable terms
- Determining what education, experience, knowledge, or ability are necessary to perform the work successfully
- Deciding which qualifications beyond the minimum are important to the particular job
- Establishing the way in which those selection criteria should be demonstrated and measured

Selection criteria are useful in tailoring the selection process to any additional necessary qualifications that might not be addressed in a general classification description. When applicants are compared to each other using selection criteria, the most qualified applicants will be those with the best combination of the standards used.

Putting It Into Practice: How do you ensure compliance with these selection guidelines in your organization?

7.6.2 Managing a Diverse Workforce

In today's global economy a diverse workforce is considered essential to a top performing organization. By their composition, cross-functional and interdisciplinary teams embrace diversity of discipline and functionality. Beyond that, teams whose membership is culturally diverse are shown to out-perform more homogeneous teams over the life of a project. Culturally diverse teams can provide insights into a diverse customer base that culturally homogeneous teams simply cannot provide.

Diversity informs decision making, expands the number of options generated during brainstorming, and adds perspectives and approaches to problem solving processes. Culturally diverse teams do not, however, function without challenge. Language barriers, a variety of perception and perspective, and a wide range of behavioral norms can serve to get multi-cultural teams off to a slow start, and sometimes lead to allegations of bias, equity concerns, and misunderstandings.

.1 Knowledge of Regional and Cultural Differences in Management Practices

Clearly, cultural differences are evidenced across international borders, but also occur regionally within national boundaries. Recognizing and responding to the cross-cultural needs of a diverse workforce can include a number of considerations to be weighed by the engineering manager. Culture refers to "the customary beliefs, social forms, and material traits of a racial, religious, or social group" or "the set of shared attitudes, values, goals, and

practices that characterizes a company or corporation."[153] Survival strategies are not easily altered. They are deeply ingrained and integrated influences that define and distinguish segments of the world population and must be managed with respect and fairness.

Edward Hall popularized the concept of "High and Low Context Cultures" in 1976.[154] He asserted that high, low, and mixed context cultures exist both nationally and regionally around the globe. Considerations of context will influence the way in which managers leads their teams.

Characteristics of High Context Cultures	Characteristics of Low Context Cultures
• Less verbally explicit communication, less written/formal information • More internalized understandings of what is communicated • Multiple cross-cutting ties and intersections with others • Long term relationships • Strong boundaries — who is accepted as belonging versus who is considered an "outsider" • Knowledge is situational, relational • Decisions and activities focus around personal face-to-face relationships, often around a central person who has authority	• Rule oriented, people play by external rules • More knowledge is codified, public, external and accessible • Sequencing, separation — of time, of space, of activities, of relationships • More interpersonal connections of shorter duration • Knowledge is more often transferable • Task-centered. • Decisions and activities focus around what needs to be done, division of responsibilities

Figure 7- 14 Characteristics of High and Low Context Cultures

Ways in Which High and Low Context Cultures Differ

The Structure of Relationships

- **High:** Dense, intersecting networks and long term relationships, strong boundaries, relationship more important than task
- **Low:** Loose, wide networks, shorter term, compartmentalized relationships, task more important than relationship

Main Type of Cultural Knowledge

- **High:** More knowledge is below consciousness--implicit, patterns that are not fully conscious, hard to explain even if you are a member of that culture

- **Low:** More knowledge is above consciousness--explicit, consciously organized

Engineering managers may be called upon to negotiate context differences that arise in values, beliefs, behavioral norms, communication strategies, use of authority and power, and individualistic versus collective orientations among team members. The goal of these negotiations is to assist workers to integrate varying perspectives and behaviors to expand the "area of possible" generated by differing approaches. Both task performance and team relationships benefit from capitalizing on diversity in this way.

.2 Knowledge of Fair Management Regulations and Practices Regarding Race, Gender, and Age

"Fair" does not mean "same." Managers are required to vary their management approaches to respond to the culturally driven needs and habits of employees. While holding all employees to the same performance standards, managers must tailor *performance feedback* in order to ensure that it is meaningful to the individual receiving it. This means that managers need to lead workers in a manner that:

- Strips away stereotypes
- Listens and probes for differences in an employee's assumptions
- Builds authentic and significant relationships with others one regards as different
- Enhances personal empowerment
- Explores and identifies differences and commonalities
- Capitalizes on identified differences rather than attempting to extinguish them

Failure to do so may result in hurt feelings, withholding of talent, rifts in productive team relationships, and even allegations of discrimination and bias. There are a number of laws that exist to protect workers from discrimination. Violation of these laws can result in costly lawsuits and the potential loss of great employees.

Laws pertaining to age, gender, disability, and race discrimination apply even if the discrimination is not intentional. There are many other labels given to other types of discrimination such as "indirect," "unintentional," "systemic", and "adverse impact." These types of discrimination refer to situations where the system, rules, regulations, policies, or arrangements have not taken into account the needs of a group protected under the law (which is virtually the entire workforce in the U.S. and Canada), or the system has not evolved with the changing society.

Putting It Into Practice: What types of diversity currently exist in the team you are managing? How are you capitalizing on the diversity within your team? What can you do to further exploit opportunities to capitalize on diversity?

Discrimination in Employment

Definition: "To decide adversely against members of a certain class because of a morally unjustified prejudice against members of that class."

Elements: A decision toward one or more employees, or prospective employees, that is not based on individual merit (e.g., seniority and experience, educational qualifications and job performance ratings), that derives from some morally unjustified attitude, such as racial or gender prejudice or stereotypes that have a harmful or negative impact on the interests of the employees by costing them jobs, promotions or pay.

Responsibilities of Managers in Preventing Discrimination

Not only are managers required to be culturally sensitive themselves, they must also ensure that employees do not act in discriminatory ways toward one another. Sexual harassment laws, for example, declare a manager is responsible if they "knew or should have known" that sexual harassment was occurring down line from them in the organization.

Under penalty of law, managers must monitor those they are responsible to and for in the organization to ensure a "safe and non-hostile" work environment. This means the manager must take any and all allegations of discrimination seriously and facilitate the prompt investigation and resolution of these complaints. Beyond that, it is incumbent on managers to be proactive in noticing and addressing situations where a potential for discrimination exists and in taking corrective action to dissipate potentially biased behaviors before allegations of discrimination occur.

.3 How to Maintain an Awareness of and Adapt to the Requirements for Managing a Diverse Workforce

There are four ways in which managers will remain aware of and adapt to the requirements for managing a diverse workforce:[183]

1. **Regularly review, refine, develop and implement policy and procedure statements that prohibit discrimination:** This involves ensuring that the organization has current and enforceable policies such as an affirmative action statement, a sexual harassment policy, a diversity policy that prohibits ageism, racism and ethno-centrism, sexism and discrimination against people with disabilities.

2. **Self-awareness and cultural awareness:** Managers must periodically examine their own level of cultural awareness and responsiveness and work to neutralize any biases that may exist in their perceptions and actions. Additionally, they should engage in continual learning about the cultural perspectives held by those they work with and manage, including customers, coworkers, subordinates, and super-ordinates.

3. **Provide learning opportunities to increase the diversity awareness and cultural competence of team members.** Developing cultural competence (appreciation of, and capitalization on, the differences and commonalities that exist in the workforce and in society) is a long term process that requires regular input of updated information through training. As laws evolve and the composition of the workforce changes, the engineering

[183] Billy Vaughn, *High Impact Diversity Consulting,* Diversity Training University International, Inc., 2006.

manager seeks out and provides ongoing training opportunities for themselves and provides similar opportunities for their staff. Regular diversity training efforts throughout an organization keep awareness of diversity issues high, reduce allegations of discrimination, ensure that all workers are valued and respected and prevent costly lawsuits and the loss of great employees.

4. **Proactively intervene in situations where the potential exists for discrimination:** Deliver timely and targeted performance feedback to swiftly limit situations or behaviors that might lead to unfair employment practices or interfere with an individual's right to a safe, non-hostile work environment.

Putting It Into Practice: How much do you know about the cultural perspectives of your direct reports? What can you do to learn more about the cultures represented in your team?

.4 Conflict Resolution Techniques

No matter how positively change is presented and initiated, there is still a strong potential for change to create conflict in an organization. Conflict can be defined as "mental struggle resulting from incompatible or opposing needs, drives, wishes, or external or internal demands"[184]

Knowledge of Common Causes and Forms of Conflict

Conflict is inevitable. By nature, it is neither good nor bad. Conflict is always a process, never an event, although when a conflict reaches its flash point it may initially be experienced or observed as an event. Conflict is composed of both content and feelings, and so it consumes energy. Conflict can be managed either proactively or reactively. In any event, it must be managed effectively in order to avoid draining time, resources, and energy from individuals within the system and from the system itself.

Common causes of conflict include values, goals, interests, strategies, structures, relationships, information, knowledge, power, and trust. Conflict can be managed or resolved, but it can't be ignored. Conflicts that are not attended to grow over time causing greater and greater losses for the individuals or organizations involved.

The conflict process manifests in phases. Unless the conflict is resolved at its peak, a repeating conflict cycle of conflict will occur.[185]

[184] Merriam Webster Online, Merriam Webster Online Dictionary, 2006.Available at http://webster.com/dictionary/conflict. Viewed 08/10/09.

[185] Cathy J. Constantino, *Designing Conflict Management Systems: A Guide to Creating Productive and Healthy Organizations,* John Wiley & Sons, Inc., 1996.

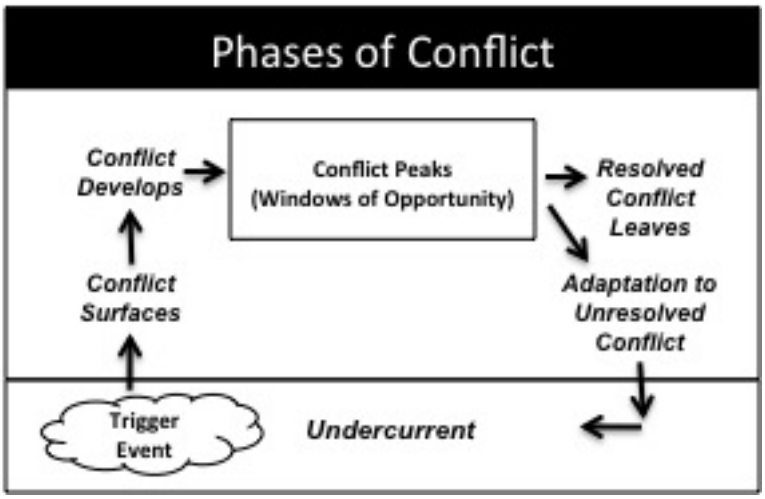

Figure 7- 15 Phases of Conflict Resolution

Conflict usually begins with a trigger event (a difference) and the conflict then begins to develop. The conflict will eventually peak. The peak of the conflict is the window of opportunity where the potential exists to resolve the conflict. If the conflict is only partially resolved, the resolved issues leave the conflict. Any remaining unresolved issues will be adapted to by those involved, and others who are impacted by the conflict. Adapting to the conflict will temporarily drive it underground where it will exist as an undercurrent and there it will either remain stagnant or grow. Eventually, another trigger event will occur and the entire conflict will redevelop, this time with even more aspects to be resolved. The cumulative impact of allowing unresolved conflict to languish causes it to grow to the point where it is progressively more difficult to manage or resolve.

Putting It Into Practice: Is there a conflict brewing in your organization? Make a plan to intervene during the next "window of opportunity" that arises.

Knowledge of Strategies for Resolving Conflict

Only five strategies exist for resolving conflict. Strategy selection depends upon the importance of the relationships and issues or tasks involved in the conflict. As a manager, it is possible to avoid the conflict only if both the importance of the relationship and the issue or task at hand are very low. Choose to accommodate others if the relationship under consideration is very important and the issue or task not significantly important. Choose to compromise if the issue or task and the relationship under consideration are both moderately important.

If the issue or task at hand is significantly more important than preserving the relationship an option is to compete with other parties. If the issue or task under debate is very important, as is preserving relationships choose to collaborate.

Assertive behavior is called for when the task is of significant importance. Cooperative behavior is called for when the relationship is significant and needs to be preserved. A mix of assertive and cooperative behavior is used when the issue or task at hand is equally as important as preserving the relationship.

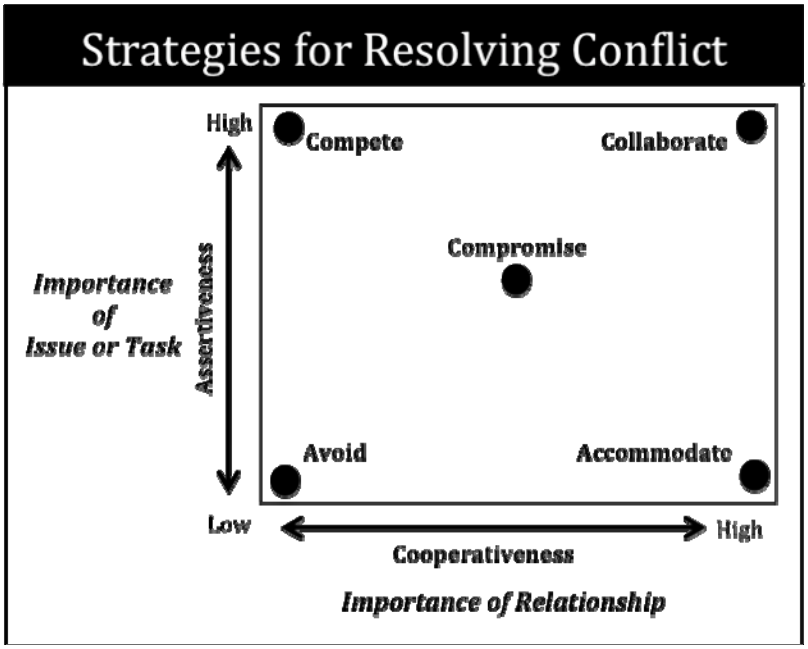

Figure 7- 16 Strategies for Resolving Conflict

During the negotiation of a complex conflict, or a conflict that involves a number of parties, it may be necessary to shift between assertive and cooperative behaviors a number of times during the course of the negotiation.

Knowledge of Role of Mediator in Conflict Resolution

Conflicts involving the manager should not be mediated by the manager. Negotiation techniques (described in section 7.7.3 of this text) are more suited to a resolving conflict where one is personally involved, or broad organizational issues are at play. The manager will take on the role of mediator when two direct reports need assistance in mediating a conflict that has occurred between them.[186]

When to Use Mediation

- When the conflict involves only two parties
- When the conflict has created a business issue that needs to be addressed
- When interdependence between parties is high
- When urgency to resolve the conflict is high and a clash has occurred

When Not to Use Mediation

- In place of discipline
- To replace job training
- To substitute for Employee Assistance Program services
- To address a poorly defined problem or issue

[186] Dan Dana, *Conflict Resolution: Mediation Tools for Everyday Worklife,* McGraw-Hill, 2001.

Manager As Mediator

- The business problem may be identified by the manager or those involved in the conflict. The manager will meet with each party prior to the mediation to hear how each defines the problem and to sell parties on the idea of attending mediation. The problem statement should be unbiased, objective, specific, resolvable, concise and written.

- The manager will choose a neutral location free from interruptions, set aside two hours for the mediation session and notify involved parties of time and location. As the mediator the manager will be impartial, will not decide the solution and will not be very active. Each employee will talk to the other, not the mediator, will stay on subject and will remain in the meeting until a solution is found. The mediator will ask the parties to speak respectfully towards the other. The mediator sits at the head of the table with problem solvers face-to-face on either side.

Beginning the Mediation

- Welcome the parties to the mediation, then read or state the problem as they understand it.
- Read or state the responsibilities of all three parties in the room and ask for agreement and acknowledgment of the roles and responsibilities of each person.
- Focus the parties on one another and ask them to begin discussing their issue.

Role of the Mediator

- Refocus the problem solvers on each other if they try to talk to the mediator.
- Refocus the conversation if it strays off of the business problem at hand.
- Recognize "conciliatory gestures" (apologizing, owning responsibility, conceding, self-disclosing, expressing positive feelings, initiating a "both gain" strategy) shown by either problem solver.
- Remind problem solvers of their responsibilities as needed.
- Ask clarifying questions as needed.
- Encourage problem solvers to keep talking when necessary.
- Wait while the problem solvers talk their issue through.
- Propose a "deal" when the parties begin to generate solutions.

On average it takes about 45 minutes to fatigue the two parties and ensure readiness to proceed to a deal. Fatigue, a desire for peace, catharsis, and inhibitory reflex all contribute to the desire to make a deal.

Making the Deal

A good deal is balanced, behaviorally specific, and written; and both parties must agree to the deal. A follow-up meeting needs to occur after the deal has had a fair amount of time to work.

During the follow-up meeting the mediator will hear from both parties as to whether the deal is working and will assist the parties in augmenting, revising, or enforcing the deal if needed.

Putting It Into Practice: Are there members of your team that are harboring conflicts that could be resolved through mediation? Develop a statement that makes a business case for mediating the conflict and present it individually to each of the team members involved in the conflict. Ask if they agree that the conflict is inhibiting the work of the team. If so, offer to meet with the conflicting parties to mediate their differences.

7.6.3 Labor Relations - Negotiation Strategies

Negotiation can be defined as "conferring with others in a way that brings about the equitable settlement of a matter." Negotiation skills help resolve situations where what you want conflicts with what someone else wants. The aim of negotiation is to explore the situation to find a solution that is acceptable to both parties. When this outcome is achieved it is referred to as a "win-win" result.

It is important to know how to leverage each step in the negotiation process to achieve a win-win outcome.

Step 1 — Preparation: Preparation involves learning as much about the other parties to the negotiation as possible. Research the wants, needs, negotiation style, possible objections and bottom line of others with whom you are about to negotiate. Additionally, know the same information about yourself and those you may be representing in the negotiation.

Step 2 — Information exchange: In the opening round of a negotiation establish rapport with other parties by engaging in a reciprocal information exchange. This step surfaces underlying interests, issues, and perceptions while looking for leverage points and identifying expectations.

Step 3 — Proposing and countering: Bargaining begins when one party introduces an initial proposal. Other parties then counter with differing proposals, with each party advocating for the most essential aspects of their offers. Concessions are offered in the form of compromises, and collaborative efforts are made to shift positions and gain as much leverage as possible.

Step 4 — Agreement and commitment: An agreement is reached that allows each party to satisfy as many needs as possible without agreeing to unsupportable conditions. Each party must then commit to taking agreed upon actions to execute and fulfill the terms of the negotiated agreement.

.1 Knowledge of Negotiation Techniques

In their book *Getting to Yes* Fisher and Ury contend that there are three negotiation techniques available to negotiators: integrative (interest-based), distributive (positional) and principled negotiation.[187]

[187] R. Fisherand and W. Ury, *Getting to Yes: Negotiating Agreement Without Giving In*. Penguin Books, New York, 1983.

- **Integrative negotiation:** This type of negotiation is structured to achieve a win-win outcome. It is used when all parties to the negotiation are motivated by joint gain and when their interests are congruent. This technique is used when a long-term relationship is to be sustained. It works well when negotiating multiple issues. The underlying concept of the technique involves expanding the pie rather than dividing it by adding value for all parties. The integrative approach is frequently used when negotiating with employees and partners.

- **Distributive negotiation:** This type of negotiation achieves a win-lose outcome with the more influential party winning the lion's share of the spoils. This technique is used when individual gain is viewed as more important than mutual gain and the interests of the parties are opposed to one another. It is most often used to negotiate a single issue and is only to be used when a relatively short-term relationship is to be sustained. Distributive negotiation divides the pie, often resulting in the party with the strongest position walking away with the greatest share of the pie. This technique was used for labor-management negotiations from the early 1900s through the 1980s in most western cultures. Today a distributive mindset may be required when negotiating cross-culturally with parties who traditionally rely on this technique.

- **Principled negotiation:** This negotiation technique is a variation of integrative negotiation and results in a win-win outcome. Principled negotiation separates people from problems and focuses on interests rather than positions. All parties to the negotiation generate a variety of options through brainstorming before making decisions. Agreements are based on objective criteria so that implementation efforts can be measured. This technique is designed to sustain and strengthen long-term relationships and expands the pie. The "best alternative to a negotiated agreement," or BATNA, is used as a walk-away option when agreement cannot be reached. Principled negotiation is often used when negotiating with customers, employees or partners.

.2 Knowledge of How to Determine and Prioritize the Needs of Key Stakeholders in the Customer Value Chain

The manufacturing industry magazine *Industry Week* (IW) published an article in September 2005 detailing the results of their 2005 Value Chain Survey. Survey findings revealed that customers in the global value chain experienced shifting priorities and changing needs over the course of the previous two years.[188] Even though a significant number of respondents cited containing cost and generating increased revenues as high priorities, the top priority was to improve customer relations. Product innovations dropped in priority while other considerations such as increased profits, reduced cycle time, increased unit volume and improved quality remained constant in the priorities list.

According to the survey, customer relationship programs are paying off. Nearly 40% of the manufacturers responding reported starting or expanding their customer relationship programs to better assess and meet the needs of their customers. They reported standard means of listening to their customers that included needs and satisfaction surveys, focus groups and one-to-one interviews.

[188] Tonya Vinas, "IW Value Chain Survey: A Map of the World," 2005. Available at http://www.industryweek.com/ReadArticle.aspx?ArticleID=10629&SectionID=11&CID=KNC-IWTRAF. Viewed 08/10/09.

In much the same manner, engineering managers can learn more about their customers and apply this knowledge to negotiations with key stakeholders in the customer value chain. Given that needs and priorities shift rapidly in the value chain, managers may need to update this information prior to entering into negotiations.

.3 How to Apply Negotiation Techniques to Ensure Win-Win Results

To ensure win-win results when negotiating with others think through the following points before you start negotiating:

Goals: What do you want to get out of the negotiation? What do you expect the other person to want? Do research to learn what others might want as you prepare for the negotiation.

Trades: What do you and the other person have that you can trade? What do you each have that the other might want? What might you each be prepared to give away?

Alternatives: If you don't reach an agreement with the other person, what alternatives do you have (BATNA)? How much does it matter if you do not reach agreement? Does failure to reach an agreement cut you out of future opportunities? What alternatives might the other person have?

Relationships: What is the history of the relationship? Could or should this history impact the negotiation? Will there be any hidden issues that may influence the negotiation? How will you handle these?

Expected outcomes: What outcome will people be expecting from this negotiation? What has the outcome been in the past, and what precedents have been set?

The consequences: What are the consequences for you of winning or losing this negotiation? What are the consequences for the other person?

Power: Who has what power in the relationship? Who controls resources? Who stands to lose the most if agreement isn't reached?

Putting It Into Practice: What negotiation strategies have you used previously? What new insights into negotiation techniques will you bring to future interactions? Why?

Review

Upon completing the study of *Domain 7: Leadership and Organizational Management*, you will be able to answer the following questions.

1. Koontz and O'Donnell argue there are six core schools of management though. List and describe each of the six schools. Which of the schools—or combination of schools—best describes your own approach to management and why?
2. List and describe the five elements of Westbrook's Integrated Management Model. What is the relationship among the elements?
3. What are the five needs that comprise Maslow's hierarchy of human needs? How might this hierarchy be useful for engineering managers?
4. What are the differences between the traditional organization structure and one that is team-based? Why is the latter better suited for technology-oriented industries?
5. Describe Likert's System IV and explain why it is the only one of the Likert management systems to consistently achieve normal productivity goals?
6. Describe the five positions on Blake and Mouton's Managerial Grid. Which of the positions is the most useful in managing knowledge workers?
7. What are some of the key characteristics of organic and mechanistic structures? Which is better suited for contemporary, technology-driven industries and why?
8. List and describe the five elements of Mintzberg's organizational design.
9. Win-win negotiation consists of a four-step process that entails comprehensive preparation, information exchange, proposing and countering, gaining agreement and fostering commitment. Describe the actions involved in each step.
10. Fisher and Ury's contend that there are three key negotiation techniques. Describe each and explain in what context each is most useful?
11. Compensation practices include both monetary and non-monetary benefits. Offerings are selected based on their perceived value to employees. How would a manager go about learning what employees value? List five benefits that are being offered in today's workplace that employees in your company might value. Why is employee retention an important consideration it today's job market?
12. The government sets fair selection and employment laws that prevent discrimination against employees. List the six types of discrimination prohibited by federal law and detail the protections provided by each law.
13. When considering what constitutes fair management practices in a multi-cultural team, the manager must be aware that "fair" does not mean "same" and will tailor management practices to meet the identified needs and norms of each employee. While holding all employees to the same performance standards, managers must tailor performance feedback in order to ensure that it is meaningful to the individual receiving it. List five considerations managers need to attend to when providing performance feedback to a multicultural workforce.
14. Four conditions must exist in order for *conflict mediation* efforts to be effective. List each of these conditions.

For Further Information

Argyris, Chris, "The Individual and Organization: Some Problems of Mutual Adjustment," *Administrative Quarterly*, Vol. 2, June, 1957.

Bennis, Warren and Nanus, Burt, *Leadership, The Strategies for Taking Charge*, Harper Collins, 1985.

Blake, Robert, and Mouton, Jane, *The Managerial Grid*, Gulf Publishing Co., Houston, 1964.

Burns, Tom, and Stalker, G.M., *The Management of Innovation*, London, Tavistock, 1961.

Covey, Steven R., *The 7 Habits of Highly Effective People*, Simon and Schuster, 1989.

Dessler, Gary, *Organization Theory: Integrating Structure and Behavior*, 2nd ed., Prentice Hall, 1986.

Herzberg, Frederick, "One More Time: How Do You Motivate Employees," Harvard Business Review, January-February, 1968.

Koontz, Harold, "The Management Theory Jungle," *Journal of the Academy of Management*, December, 1961.

Kouzes, James M. and Posner, Barry Z., *The Leadership Challenge*, Jossey and Bass, 2002.

Taylor, Frederick W., *Shop Management,* Harper and Brothers, New York, 1911.

Lawrence, Paul R., and Lorsch, Jay W., *Organization and Environment*, Harvard University, 1967.

Likert, Rensis, *New Patterns of Management*, McGraw Hill, Inc., 1961.

Maslow, Abraham H., "A Theory of Human Motivation," *Psychological Review*, Vol 50, 1943.

McClelland, David, "That Urge To Achieve," *Think Magazine*, IBM Corporation, 1966.

McGregor, Douglas M., "The Human Side of the Enterprise," *Management Review*, November, 1957.

Mintzberg, Henry, "Managerial Work: Analysis From Observation," *Management Science*, vol. 18, no. 2, October, 1971.

Mintzberg, Henry, *The Structure of Organizations*, Prentice Hall, Englewood Cliffs NJ, 1979.

Mintzberg, Henry, *Structures in Fives: Designing Effective Organizations*, Prentice Hall, Englewood Cliffs NJ, 1983.

Pugh, D.S., Hickson D.J., Hinnings, C.R., and Turner, C., "The Context of Organizations," *Administrative Science Quarterly*, vol. 14, 1969.

Quinn, James Brian, Doorley, Thomas L., and Paquette, Penny C.; "Beyond Products: Services Based Strategy," *Harvard Business Review*; March-April, 1990.

Skinner, B.F., *Science and Human Behavior*, McMillan, New York, 1953.

Westbrook, Jerry D., "An Integrated Theory of Motivation", *Engineering Management International*, vol 1, 1982, 193-200; Elsevier Publishing Company, Amsterdam.

Domain 8: Professional Responsibility, Ethics and Legal Issues

Domain Champion: Nael Barakat, Ph.D.

8.1 Professionalism

- 8.1.1 Continuous Professional Improvement
- 8.1.2 Certification, Accreditation, Licensure
- 8.1.3 Ethical vs. Legal

8.2 Compliance Procedures

- 8.2.1 Knowledge of topics typically covered in procedure documents
- 8.2.2 Interpreting and applying procedures in engineering projects

8.3 Regulatory Requirements, Codes, and Standards

- 8.3.1 Knowledge of regulatory and industry standards involving safety and the environment
- 8.3.2 Communicating standards and training direct reports
- 8.3.3 Monitoring and enforcing standards
- 8.3.4 Addressing violations
- 8.3.5 Improving adherence to standards

8.4 Business Contract, Patent, Copyright, and Trademark Laws and Intellectual Property

- 8.4.1 Knowledge of contract, copyright, trademark laws, patents
- 8.4.2 Interpreting and applying laws within the context of contract and project requirements
- 8.4.3 Ensuring that intellectual property is adequately protected

8.5 U.S. and International Codes, Standards, and Regulations

- 8.5.1 Knowledge of international standards, codes, and regulations
- 8.5.2 Knowledge of U.S. standards, codes, and regulations for working with international companies (non-U.S.)
- 8.5.3 Applying standards to international engineering projects

8.6 Professional Codes of Ethics; Professional Liability

- 8.6.1 Knowledge of professional ethical standards and corporate codes
- 8.6.2 Applying and enforcing standards when dealing with ethical or professional liability issues involving direct reports
- 8.6.3 Applying and enforcing standards when dealing with ethical or professional liability issues in international engineering projects

Domain 8: Professional Responsibility, Ethics, and Legal Issues

Key Words and Concepts

Code	Related groups of standards usually created by experts in the particular field and then adopted by governmental bodies
Code of Ethics	Code outlining what is ethical behavior for persons in a profession—usually developed by a professional membership organization
Copyright	The exclusive legal right to reproduce, publish, and sell original work created by a writer (e.g., computer software, literary works, artistic works, etc.)
Governmental Regulations	Rules formulated and issued by a governmental agency—typically have the force of law
Key Performance Indicators	Quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organization
Patent	The exclusive legal right to make, sell or license novel and useful inventions
Standards	Descriptions established by authority, custom or general consent as a model of performance, quality, etc.; also an established rule of measurement
Terms and Conditions	The various clauses that collectively make up a contract
Trademark	The exclusive legal right to use an identifying mark (logo, symbol, product name) as long as it is kept in use

8.1 Professionalism

Linguistically, professionalism means the standing, practice, or methods of a professional distinguished from an amateur. Culturally, it means the expertness characteristic of a professional performing a profession, regardless of the task or job they perform. In the context of engineering and management, a profession has particular attributes that distinguish it from other jobs and expertise. These attributes include:

1. Membership requirements:
   - Extensive formal education and training of intellectual character.
   - Sophisticated skills, autonomy, and use of judgment; not routine.
2. Public and society view:
   - The knowledge and skills of the members are vitally needed for society well-being.
   - Professional organizations are allowed to self-control and regulate the practice.
3. Professionals are normally regulated by ethical standards, embodied in a Code of Ethics.

   Examples of professions include engineering, medicine, and law. These professions have an implicit contract of trust with society to practice according to the highest professional standards. It is also understood that they will self-regulate their profession in exchange for guarding and protecting the health and welfare of the public. Some of the ethics and standards of practice for these professions are enforced by laws; others are self-imposed. Regardless of the enforcement mechanism, all professionals must fully understand that their actions, the image they convey to the public, and the physical impact they have on the public's health and welfare, will either influence the public's trust in the profession or the opposite. For these reasons and many others, it is the responsibility of every engineer and engineering manager to apply and promote the ethics of the profession as part of his or her professional practice.

8.1.1 Continuous Professional Development

In the twenty-first century, continuous professional development (CPD) is fundamental to survival in all profession, and engineering is no exception. To remain commercially and professionally viable, engineers must stay abreast of the latest advances in their field, including changes in the knowledge base and advances in the tools of their trade. To do otherwise would be to jeopardize one's reputation and career.

Staying current is also a central tenet of the engineer's professional code of ethics. Practicing engineering based exclusively on the tools and knowledge acquired during one's first engineering degree would breach this code and pose a clear ethical problem. In specific, practicing with outdated tools, skills, and knowledge, would be a practice outside ones limits of expertise. To reinforce the ethical importance of life-long learning, CPD is currently required for professional engineers' registration in most states and is an accreditation requirement for engineering schools and programs.

Engineering managers should establish CPD as a standard practice and benefit for members of their engineering team. In exchange, the employer would enjoy a number of benefits, including a more stable and continuous workforce, as well as a competitive advantage in the marketplace. It would also make the firm more attractive to highly skilled job candidates and establish it as a leader in the field.

Numerous opportunities exist for engineer's to upgrade their knowledge and skills. For example, professional organizations and educational institutions have established ongoing programs. Examples of these programs include the short courses offered by ASME. Other examples include Career enhancement short courses and certification by IEEE and SME, to name a few.

It should be noted that CPD activities are frequently carried out by professionals on an ad-hoc basis, usually as part of a job or accreditation requirement. However, for engineers to survive in this century, continuous learning should be performed as a way of life. Within an engineering practice, this means incorporating CPD into each of its engineer's career development programs.[189]

8.1.2 Certification, Accreditation, and Licensure

Because the engineering profession has a significant impact on the health and welfare of the public, it is logical that the practice would be regulated as a means of protecting both the public and its practitioners. As a profession, self regulation is the norm with engineering, with legal enforcement functioning as an extension of the self-regulation that guarantees its organized application.

Engineering regulation starts at the education stage where schools and programs of engineering are monitored and accredited through a specialized organization. In the USA, this organization is the Accreditation Board of Engineering and Technology (ABET). ABET is a federation of 29 professional and technical societies representing

fields of applied science, computing, engineering, and technology. ABET is also the recognized accreditor for these fields. ABET is recognized internationally and has reciprocity with multiple internationally equivalent organizations (e.g. Canadian Engineering Accreditation Board (CBET), Engineering Council of UK (ECUK), etc!).

Once an engineer graduates from a college or university, he or she acquires a license to practice by following a set procedure and passing a qualifying exam. These licenses are governed in the USA by professional organizations and governmental agencies through the National Council of Examiners for Engineering and Surveying (NCEES). NCEES supervises and organizes the actual examination. However, the final decision of granting the license is controlled by each state with variations depending on the states laws and requirements. Other countries have similar procedures and organizations. An engineering manager should know that the licensed engineers are the only engineers allowed to work on governmental projects dealing directly with the public. Although many engineers practice without this license, public projects are not open to them.

[189] For further CPD references, check the web sites of your respective professional organization or engineering licensing board. You can also refer to: Barakat N., "Merging Continuous Professional Development into Engineering Education and Practice," ASEE-NCS Annual Conference, Grand Rapids, MI. 2009.

Certification is a sub-level of accreditation or a testimony of professional achievement. It is usually required by law to practice specialized areas of engineering, to conduct specific procedures, or to operate specific, sophisticated or dangerous machinery. Engineering managers should be aware of these specially regulated areas, especially when handling projects that deal directly with the public.

8.1.3 Ethical vs. Legal

This is a common mix-up that engineers and engineering managers need to be very clear about in the practice of their profession. Legal regulations are at a level that is usually very close to ethical regulations and code, but not exactly the same. To start with, legal regulations are usually a result of ethical infractions and issues that evolved during the practice of the profession. However, most legal regulations are re-active in nature while ethical code content tends to be more anticipatory and pro-active in its views. This is not necessarily bad or wrong. The nature of legal enforcement requires significant prudence, proofs, and involves more public representation and resources compared to ethical codes of the profession.

A common example of a legal but not so ethical action is the dumping of toxic waste in lakes that is below legal limits set by the EPA. The difference between legal infractions and ethical infractions is almost the same in its detrimental nature and long term effect on the public and the professionals. However, legal infractions are more personal, faster uncovered and prosecuted, and more visible to the public than ethical infractions.

We should note that the distinction between legal and ethical regulation varies in an international context. Some ethical infractions in the USA are considered legal infractions elsewhere and vice verse. A common example that frequently confuses engineers practicing internationally is the problem of differentiating between a gift and a bribe. While the distinction between gifts and bribes is clearly defined by the majority of businesses in the USA, in some countries the distinction is not as clear. Some nations view highly priced gifts as a common business practice, which in the USA or other nations, they would be considered a bribe which is a crime punishable by law.

8.2 Compliance Procedures

Company policies and procedures are the formal rules that govern employers and employees. In the past, these policies and procedures were kept in cumbersome three-ring binders. Today, their creation and maintenance is made far more efficient and effective via the use of databases, software and web-based packages. This makes the revision process easier, increases their accessibility and facilitates their integration with other computer-based management systems (e.g., human resources, project planning).

8.2.1 Knowledge of topics typically covered in procedure documents

Procedure documentation is an organizational necessity. While employees are often frustrated by the seemingly endless process of procedural documentation, most engineers agree that the process offers numerous benefits. Procedure documentation covers a wide range of operational topics, many of which are listed in Figure 8-1.

Procedure Document Types

- Accounting and Finance
- Process Improvement
- Computers and IT
- Procurement and Purchasing
- Disaster Recovery
- Product/Process Evaluation
- Employment Practices
- Project Management
- Human Resources
- Quality Improvement and
- Internal Control Checklists and Control Evaluation Tools
- Risk Management
- Logistics
- Sales and Marketing
- Manufacturing and Production
- Security Planning
- Operations and Facilities
- Strategic Planning

Figure 8- 1 Procedure Document Topics

Process document elements

Formats for process documentation are designed to meet the needs of the specific process or organization and, thus, vary widely. That said, most procedure documents include the following elements:

- Name of author
- Dates developed and modified
- Brief description of intended audience and implementer
- Purpose
- Detailed steps including useful diagrams, renderings, tables, etc.
- List of related processes references

Several companies offer easy-to-use software and web-based packages that include templates for creating process documentation. The templates both simplify standardize the process or creating and maintaining these documents.

8.2.2 Interpreting and applying procedures in engineering projects

Well-written procedures are an important part of creating well-defined processes that conform to industry *standards* and *governmental regulations*. Because there are many different *codes* or standards that must be accounted for—e.g., regulatory requirements, national agency standards, state regulations, city regulations, federal guidelines, military standards, etc.--engineering project procedures are often more important to document than non-engineering projects.

When applying procedures in engineering projects, there are basic laws-of-nature requirements that are fundamental. For example: Will the bridge withstand hurricane force winds? Will the building hold up under a magnitude 6.5 earthquake? How much floodwater will the dam hold before bursting? How much shear can the airplane take? Will the electrical circuits survive a lightening strike?

Well-crafted procedure documentation also facilitates continual process improvement activities. Inspire employee buy-in by reminding staff of the many benefits of procedure documentation (Figure 8-2).

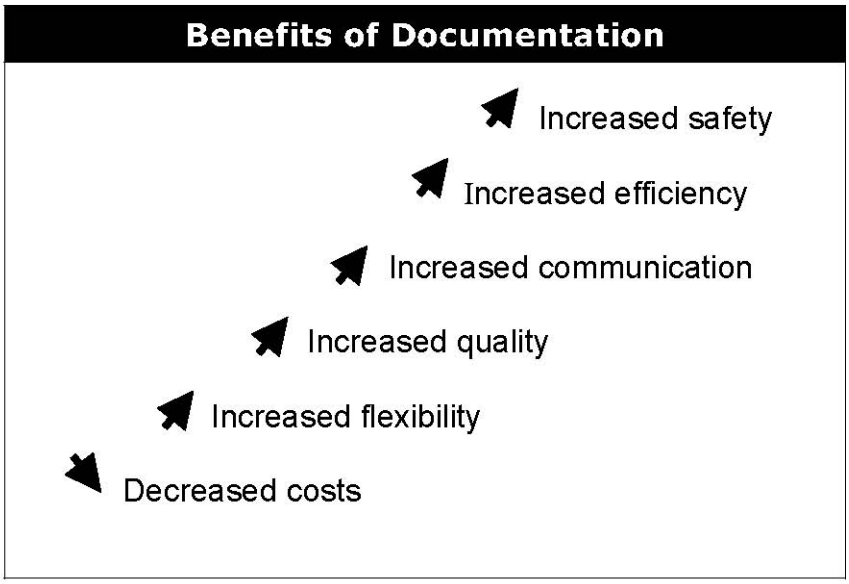

Figure 8- 2 Benefits of Documentation

.1 Importance of Following Procedures Documentation Carefully

In general, only those procedures that are critical to project success or need to be repeated require documentation. It is vital that such procedures be carefully followed, as they have been created to prevent costly and dangerous errors.

For example, a plant manager, a logistic manager, a production supervisor, and a unionized chemical blender were each charged with multiple felonies and arraigned in an incident that stemmed from not closely following procedure. A new transport company brought in a bulk load tanker truck to carry an acid-based product to a customer from a chemical blending plant. For reasons never determined, the logistics company sent an aluminum tanker that

looked just like a stainless steel tanker built to carry hazardous chemicals. It was loaded outside on a cold, snowy January day by a chemical blender who did a cursory job covering his ten-point inspection policy. The truck disintegrated on the highway 500 miles from the starting point, creating a chemical spill. After millions of dollars in cleanup, litigation, fines by state, county, and federal agencies, along with fingerprinting and mug shots of the four "criminals," the case was finally closed. The end result: each load of bulk chemicals shipped from the facility is now subject to intense scrutiny and signoff. If procedures had been followed in advance, this incident could have been avoided.

To ensure that employees are carefully following established procedures and focused on meeting standards, managers must document training activities. Only with clear procedures and consistent follow through will managers effectively train, coach, and monitor the staff they supervise.

Putting It into Practice: What do you need to do to ensure that staff carefully follow procedures?

8.3 Regulatory Requirements, Codes, and Standards

Standards are essential to the complex business operations of the 21st century. Standards are designed to:

- Improve process efficiency
- Ensure interchangeability
- Protect employers, consumers, and the environment

Industry (voluntary) standards: Voluntary standards are usually industry standards that regulate how a product must perform and/or be manufactured. Industry standards are considered to be the compilation of industry-wide wisdom as to how to evaluate industry products. Although voluntary in name, an industrial standard issued by a very powerful or prestigious body may become virtually mandatory due to industry or consumer pressure.

Regulatory (mandatory) standards: In contrast, regulatory standards are usually issued and by governmental bodies and have the force of law. Traditionally, governmental standards have been related to safety and health issues, but in more recent years, have grown to include environmental protection. The two most common types of governmental standards are codes and regulations.

It should be noted that certain voluntary standards in one country may be mandatory in others.

8.3.1 Knowledge of regulatory and industry standards involving safety and the environment

Engineering managers must remain aware of current safety and environmental codes and standards. Ignorance of the law is no excuse, nor is the unacceptable justification that the company has been acting in violation of such codes and standards for years. Failing to comply with these regulations has a variety of detrimental consequences, not the least of which is criminal prosecution and plant shutdowns.

The Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) are familiar U.S. Government offices charged with protecting the public well-being. In addition to these agencies, industry professionals should also be aware of and conform to safety, environmental, and other regulatory standards developed by several other groups, including:

- National Fire Protection Association (NFPA)
- Consumer Product Safety Commission (CPSC)
- Food and Drug Administration (FDA)
- National Institute of Standards and Technology (NIST)
- Electronic Industries Alliance (EIA)
- Controlled Environment Testing Association (CETA)
- Equal Employment Opportunity Commission (EEOC)
- International Association of Plumbing and Mechanical Officials (IAPMO)
- American Society of Mechanical Engineers (ASME)
- American National Standards Institute (ANSI)

See Figure 8-3 for additional federal, state and local government regulations resources.

Federal, State and Local Government Regulations Resources
ASSIST Online (Acquisition Streamlining & Standardization Information System)[190] • A comprehensive database on military and federal specifications and standards. It is the official source for U.S. Department of Defense standard • http://assist.daps.dla.mil/online/faqs/overview.cfm
Code of Federal Regulations (CFR)[191] • A database of permanent and general rules issued by federal agencies. • http://www.gpoaccess.gov
FirstGov.gov[192] • Federal website offering links to information about state and local governments and agencies, including a link to lists of state agencies organized by topic.

[190] ASSIST Online provides downloadable information about Department of Defense specifications and standards. The site requires the searcher to establish an account and password. Available at http://assist.daps.dla.mil/online/faqs/overview.cfm. Viewed 08/10/09.

[191] The Code of Federal Regulations (CFR) database allows the searcher to access permanent and general rules issued by federal agencies. Available at http://www.gpoaccess.gov/cfr/. Viewed 08/10/09.

[192] The federal website FirstGov.gov has tremendous resources for searching, including a number of links to information about state governments. Available at http://www.firstgov.gov. Viewed 08/10/09.

• http://www.firstgov.gov/Agencies/State_and_Territories.shtml
Council of State Governments (CSG)[193] • The CSG provides easy links to all state websites. • http://www.csg.org/CSG/States/state+pages/default.htm
International Code Council (ICC)[194] • A composite of what used to e Building, Officials and Code Administration (BOCA), International Conferences of Building Officials (ICBO), and Southern building Code Congress International (SBCCI) • http://www.iccsafe.org/

Figure 8- 3 Federal, State and Local Government Regulations Resources

States, municipalities and other local governments are likely to issue their regulations as a set of codes, such as building or zoning codes. Approach local sources directly in order to determine which codes are applicable in your area.

.1 Safety Requirements

Many countries have adopted standards designed to ensure the safe operation of facilities in which companies operate. In the USA, the Occupational Safety and Health Administration (OSHA) was created in 1970 to be the leading government agency that develops and administers regulations governing worker safety. OSHA's mission includes "setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health."[195] See Figure 8-4 for examples of safety areas that OSHA regulates.

Examples of Safety Areas OSHA Regulates	
• Eye and Face Protection	• Fire Safety
• Ergonomics	• Hazard Awareness
• Evacuation Plans and Procedures	• Electric Power Generation
• Noise and Hearing Conservation	• Steel Erection
• Repository Protection	• Machine Guarding

Figure 8- 4 Examples of Safety Areas Regulated by OSHA

[193] The Council of State Governments provides a chance for states to share information and work together to solve state and regional problems. The website also provides easy links to the official websites of all the states. Available at http://www.csg.org. Viewed 08/10/09.

[194] The International Code Council (ICC) is a composite of what used to be Building Officials and Code Administrators (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International. They publish a wide variety of building-related codes for American and international use. Available at http://www.iccsafe.org/. Viewed 08/10/09.

[195] Occupational Safety and Health Administration (OSHA). Available at http://www.OSHA.gov. Viewed 08/10/09.

The OSHA website (http://www.OSHA.gov) offers access to a variety of informational tools to help companies understand and comply with regulations, including:

- eTools
- OSHA Safety and Health Topics Pages
- OSHA Recordkeeping Handbook

Putting It into Practice: How would you assess safety at your company? What can you do to improve safety at your workplace?

.2 Environmental Regulations

Environmental regulation strives to ensure that companies do not harm the environment in which they operate by discharging harmful wastes, producing excessive noise, wasting scarce natural resources, etc.

In the U.S., the Environmental Protection Agency (EPA) is the leading office charged with establishing and enforcing environmental protection standards. The EPA website (http://www.EPA.gov) provides a variety of resources to help researchers access applicable regulations.

Within organizations, establishing environmental policies and procedures can reap dividends for the company in increased levels of employee satisfaction, enhanced reputation within the community and greater customer satisfaction.

Follow this three-step process to develop an organizational environmental policy:

Step 1: Enhance environmental awareness through

- Developing management leadership
- Encouraging employee involvement
- Sponsoring employee training

Step 2: Develop environmental strategies by

- Communicating clear goals
- Developing environmentally-oriented methods and processes
- Prioritizing tasks and creating action plans

Step 3: Conduct environmental audits by

- Setting measures for success
- Conducting audits and giving feedback to participants
- Developing continuous improvement targets

8.3.2 Communicating Standards and Training Direct Reports

Engineering managers, unfortunately, have no single all-encompassing source to access thorough and timely information about the wide range of standards and regulations they are required to meet. Dependent upon the industry, different regulatory agencies are involved. For example, the aerospace industry follows many military specifications for design and testing of aircraft; while pharmaceutical companies are monitored by the FDA (Food and Drug Administration) and must follow GMP (good manufacturing practices).

Most organizations preserve information about standards applicable to their specific job site. How the information is disseminated and managed varies.

Internal standards are often maintained on the company intranet and can include descriptions of processes as simple as filling out expense reports to precise electrical test procedures for interpreting diagnostics of radio feedback waves. Engineering companies often have an internal group dedicated to interpreting standards. See Figure 8-5 for a list of possible regulatory requirement information resources within an organization.

Regulatory Requirement Information Resources
• A centralized standards office • A standards updating website/service (Techstreet, IHS, etc.) • Company legal advisor(s) • Job site documentation (databases, websites, manuals, etc.) • A designated staff member • Supervisory staff

Figure 8- 5 Accessing Regulatory Requirements

.1 Internal Standards

While companies have numerous industry standards to adhere to, most organizations develop additional internal performance standards to guide staff actions. Of course, standards related to management systems may be less precise than standards used for testing different grades of steel. However, even standards for management systems define what is expected and provide methods for measuring success.

The most effective standards begin with what is mandated, and are further developed to include standards that would benefit the specific job site, maximize efficiency in use of natural resources, etc. Investing the resources to develop effective internal standards can give companies a decided edge in a competitive marketplace.

When drafting standards, or revising them as part of process improvement activities, follow the checklist below.

- Consider the frequency with which the standard will be used (e.g., rarely, regularly, intermittently, etc.)

- Consider the knowledge and experience of users (e.g, novice, expert, etc.)
- Structure the standard in an easy-to-read format
- If modifying an existing standard, allow for customization to meet the requirements of the specific workgroup or task, when appropriate
- Design metrics to use when assessing whether standards have been met
- Clarify accountabilities and responsibilities
- Circulate drafts among staff for input and feedback. Be sure to determine a due date for responses.
- Check and double check.

.2 Training Staff

Whether introducing a new set of standards to employees or a new employee to the existing standards, remember that human beings have limited abilities for information retention. Take into consideration the amount of information the individual can reasonably absorb and retain at any given time. Explore using existing communication and training resources. For example, OSHA (http://www.osha.gov) has numerous materials that can be used to train staff, including videos and PowerPoint presentations.

.3 Steps for Standards Training

- Begin with an orientation session where the "larger" topics and issues are discussed. If necessary, introduce standards in stages and leave smaller details for later training sessions.
- Share standard goals and discuss how standards are intended to meet those goals.
- Discuss the scope of the standard — who the standards apply to and who they will be implemented by.
- Use visual aids to boost learner retention.
- Provide staff with job aids — or show them where informational resources are located.
- Give hands-on experience whenever possible. If learners are to be using forms, web-based tools, safety equipment, software applications, etc., give them opportunities to practice using the actual items.

.4 Reinforcing Standards Training

- Offer refresher training sessions.
    - Make reviewing standards a regular part of weekly or monthly meetings.
    - Schedule monthly standards meetings.
- Weave standards training into existing training activities.
- Have job aids and documentation readily available — especially for emergency processes.

Putting It into Practice: How are standards communicated and updated in your organization? What actions will you take to better train and support the people who report to you?

8.3.3 Monitoring and Enforcing Standards

Standards today typically contain at least two elements: (1) the design of the standard itself, *plus* (2) specific built-in methods for measuring whether, or how well, the product, process, or employee performance conforms to that standard. Engineering managers are entrusted with the task of ensuring that standards are maintained and followed. Planning and monitoring are key to doing this successfully..

As shown in Figure 8-6, engineers and their staff must first collect system, process and/or employee performance data. Once the data has been collected, engineering mangers then evaluate the results by comparing them to the standard.

An examination of why a standard is not being met will dictate the appropriate course of action. On the one hand, a single adjustment to a piece of equipment or a gentle employee reminder may be all that's required. On the other, a thorough re-evaluation of an entire process might be in order.

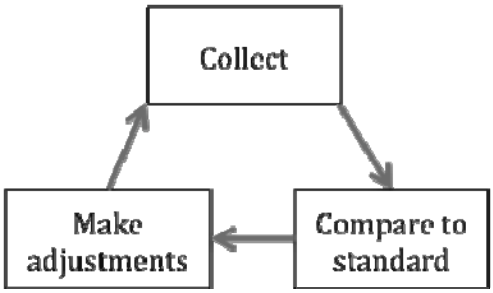

Figure 8- 6 Enforcing Standards

Today's engineering managers have access to numerous tools to help them monitor personnel and process performance. Computers are used to store and communicate standards; and various other technologies provide automated processes to measure adherence to or variation from standards. These systems are also used to monitor system status and relay messages when a product or process is out of its defined parameters and requires intervention.

Encouraging Staff Compliance

Employee commitment to performance standards is vital to their achievement. They must see that the company is committed to meeting standards and will back up that commitment with enforcement. To effectively enforce these standards, do the following:

- Develop clearly articulated *key performance indicators (KPIs)*.
- Review process design to ensure that performance indicators are reasonable.
- Make sure that staff understands stated KPIs and why they are being used.
- Keep staff on track by making KPIs highly visible.
- Create structures for encouraging staff compliance, such as checklists, inspection schedules, planned and unplanned reviews/inspections, etc.
- Reward desired behaviors. Tie bonus programs or other incentives to compliance with safety practices and meeting a variety of standards. (For example, observe and reward

staff who are wearing the necessary personal protective equipment (PPE) — which is useless if staff are not using it properly.)

- Link staff compliance with procedures to performance evaluation and address at each performance review.

8.3.4 Addressing Violations

.1 Regulatory Violations

Consequences of regulatory violations vary widely depending on the severity of the infraction. Plants can be shut down if GMP's (good manufacturing practices) are compromised, or ISO (International Organization for Standardization) accreditations can be taken away for multiple incidents of non-compliance. Tyson, World Com and Enron executives have faced trials for what would now be a breech of the Sarbane-Oxley Act.

Any actions taken to address violations in regulatory codes and standards must respond directly to the requirements expressed by the governing body. Be sure to review communication carefully, create a team to address the issue(s), consult internal and external experts, and resolve the issue(s) as expediently and carefully as possible. Avoiding further negative consequences is a priority for the organization.

.2 Staff Violations

Employees are human beings and, hence, will make errors or occasionally become less vigilant when completing their tasks. When standards are not met due to deficiencies in employee performance:

- Assess supervisory activities to determine whether employees have been supported appropriately in a manner that will enable them to meet standards.
- Examine systems to uncover any inadvertent disincentives to compliance with standards.
- Address violations swiftly and severely. Be careful to be fair and appropriate when correcting behaviors.

Rules and guidelines are most effective when they are extremely visible, communicated clearly and understood by all. Make it abundantly clear to staff that appropriate punitive actions for violations will be employed. So the staff understands the outcome of violations, managers must communicate their knowledge of the violation and describe corrective actions taken.

Managers serve as role models for their staff who are striving to achieve company and regulatory standards. Be careful to:

- Be well informed about the standards and procedures, seeking out input from other sources as necessary.
- Ensure that standards are reasonable, measurable, and accurately create a description of the expected work performance.

- Apply standards consistently and fairly to all concerned.
- Document actions taken by all involved parties. These might include Parties explaining the standards; applying, monitoring, and assessing their application; and/or punishing violations

Many individuals who find it challenging to meet standards need a bit of extra support and coaching from their supervisors. When giving constructive corrective feedback to staff, be direct, specific, respectful of the employee and definitive about actions to be taken. Be sure to follow up and compliment team member for their accomplishments.

Putting It Into Practice: What can you do to minimize the number and severity of standard violations where you work?

8.3.5 Improving Adherence to Standards

Improving adherence to standards is a group effort. As opposed to addressing individual performance, teams of employees commit to examining procedures and implementing process improvements. However, corporate culture and attitude play a major role in encouraging and building a practice of monitoring standards and adhering to them as closely as possible. Therefore, a significant part of the responsibility for applying standards is shared by the corporate culture, which automatically becomes another piece in the upper management responsibility.

For example, a computer system can assess how orders are being received into the warehouse and monitor the level of on-time deliveries. If a discrepancy is found between the standard (the expected result) and the actual performance, the manager may communicate with the supplier. Together they could develop a plan to achieve the standard, in this case, increasing the number of on-time deliveries. The improved adherence to the standard would then involve a collaborative problem-solving team. Key people from the suppliers work with the customer to identify reasons for late deliveries and take corrective action to improve results. Figure 8-7 illustrates a general management team model that can be utilized to toggle and solve and problems stemming from non-adherence to standards.

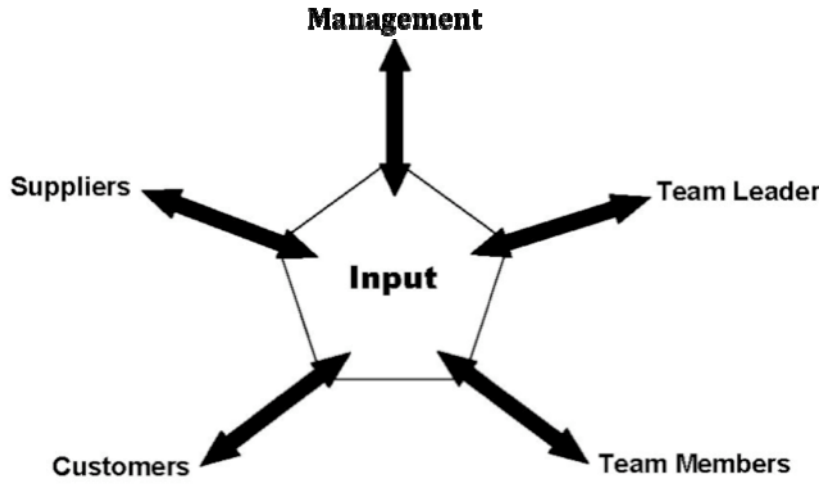

Figure 8- 7 Standard Management Teams

Because adherence to standards is vital to both project and organizational success, engineering managers must make addressing these issues a high priority. Whether ensuring adherence to a mandatory regulatory standard or a voluntary industry standard, management will have to both prepare and continually retrain its staff on applicable standards.

.1 Preparing staff for standards adherence

Prepare staff for adhering to standards by:

- Enlisting commitment of top management
- Assigning department or team ownership of standard maintenance and communication
- Creating teams or committees to monitor organizational activities
- Designating a team leader and delegating accountability
- Reviewing established processes
- Planning for emergencies
- Ensuring process documentation is readily accessible to staff
- Making critical information highly visible
- Developing clearly articulated key performance indicators (KPIs)
- Setting up control charts to monitor process
- Setting up a statistical process control (SPC) project on adherence to standards

.2 Maintaining staff adherence to standards

Given the fact that human as well as mechanical systems tend to break down, they all tend to need a bit of fine tuning on a regular basis. Maintain staff adherence to standards by:

- Scheduling regular meetings to review and assess adherence to standards
- Having data monitored and collected to view trends/patterns
- Using safety incidents, production shortfalls, variability in outputs, etc., to assess problems in the system and plan and implement improvements
- Regularly conducting training refreshers
    - Bringing discussion of various standards into regular staff meetings to keep staff conscious of key topics
    - Being creative
    - Delegating responsibility for mini-trainings to staff
    - Keeping training sessions engaging and fun, as well as productive

8.4 Business Contract, Patent, Copyright, Trademark Laws, and Intellectual Property (IP)

Business law takes on many forms and regulates a vareity of business entities and commercial transactions. Laws are designed to protect all parties through directing how *terms and conditions,* specific performance expectations, breach of contract agreements, etc., will be articulated.[196]

Intellectual Property laws differ from country to country, complicating the issue for engineers and others. The U.S. Patent and Trademark Office regulates the issuance of domestic intellectual property rights in the USA. On an international level, The World Trade Organization (WTO) and the World Intellectual Property Organization (WIPO) encourage members to establish and enforce minimum levels of *copyright, patent,* and *trademark* protection within their jurisdictions.

8.4.1 Knowledge of contract, copyright, trademark laws, patents

.1 Contract Law

Contract laws are generally well-defined and specific. When entering into contracts, it is always best to engage the services of a lawyer or a member of the corporation's in-house legal team. The various clauses that collectively make up a contract are called terms and conditions (Ts and Cs). Many companies have standard Ts and Cs on hand to use when requesting proposals from suppliers and beginning contract negotiations with customers.

Common Ts and Cs:

- Work Specifications
- Deadlines
- Delivery Terms
- Price and Payment Terms
- Standards and Codes to be Followed
- Warranties
- Indemnification Clauses
- Force Majeure Clauses

Indemnification and force majeure clauses are designed to protect contracted parties by creating provisions for circumstances when the contract cannot be fulfilled in accordance with the original agreements.

[196] "Business Law," Encyclopædia Britannica, 2006. Available at http://www.britannica.com/eb/article?tocId=9358382 (Encyclopædia Britannica Premium Service). Viewed 08/10/09.

.2 Patents, Trademarks, and Copyrights

Intellectual properties are valuable business assets (see Figure 8-8). They are the products of creative thinking.

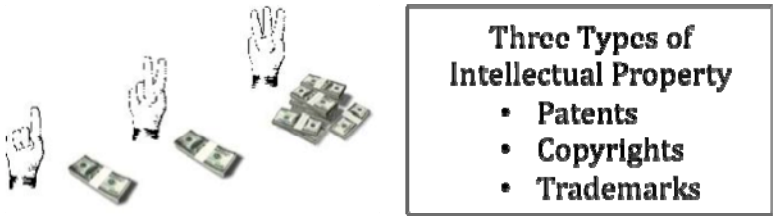

Figure 8- 8 Three Types of Intellectual Property

Patents, trademarks, and copyrights, while all forms of intellectual property, are addressed differently in domestic and international legal systems. Because engineering managers work regularly with an array of ideas and technology that are company assets, understanding the distinctions and becoming familiar with intellectual property practices will prevent accidental complications.

Patent law states:

Patents are obtained for an invention or design that is novel and useful — not obvious. The patent holder has exclusive rights to make or sell (in U.S.). Rights are held: 20 years for an invention, 14 years for a design. Individuals or organizations who infringe are liable for lost profits and attorneys fees.

Trademark law states:

Trademarks protect the developer/user of an "identifying mark." Trademarks are applied to products, symbols and logos (e.g., product: Kleenex; symbol: the Nike "check-mark"; logo: the ASME logo). Violators will be required to stop using the trademark and pay damages related to profits made while using the mark.

Copyright law states:

Copyrights are awarded to authors and artists for their work (music, computer programs, writings of many sorts, photos, etc.). Authors maintain rights for their lifetime plus 70 years. Publishers' rights continue for 95 years after publication or 120 years from creation. Damages to be paid for infringement could include lost profits and legal fees. Intellectual property is protected at the international level by several conventions and treaties. An array of agreements permits individuals of member countries to file for protection in other member nations. For example, conventions at Paris and Berne created agreements for international patent and trademark protection and the World Intellectual Property Organization (WIPO) negotiated copyright protection for computer programs.

8.4.2 Interpreting and applying laws within the context of contract and project requirements

The contract management process (Figure 8-9) can be described as having three stages:

Figure 8- 9 Contract Management Stages

Negotiation: involves all parties responsible for clarifying and reaching consensus on the contract requirements and components.

Formation: brings together the understandings reached in negotiation and commits them to written/documented form.

Administration: requires that all parties strive to ensure that the terms and conditions agreed upon are met.

The U.S. legal system strives to maintain an effective balance between the rights of the individual and the needs of society. This dynamic interaction dramatically influences our approach to business interactions as well. The resulting relationship between business contracts and the laws that govern them is also dynamic, as much is open to interpretation. Therefore, the most effective engineering managers develop the fine art of negotiation. The engineer's role in contract development and management is to advocate for the company's advantage — while still maintaining a balanced, "win-win," and ethical perspective. At the same time, it cannot be stressed enough how vital it is for engineers to enlist the support of contract law advisors.

Putting It Into Practice: What are the structures at your company for ensuring that contract legalities are addressed by legal support staff?

.1 Managing International Contracts

Engineers working with international contracts should be mindful of the differences between domestic and international contract practices (see Figure 8-10):

Domestic Contracts	International Contracts
Written contract required for service of >1 year and > $500	Written sales contracts are not required
Acceptance of contract is indicated by signatures	Written contracts do not need to be signed

Figure 8- 10 Domestic Versus International Contracts

Approaches to disagreement litigation vary from country to country. For example, the U.S., Britain, and Canada operate within a common law system, where court opinions are largely based on precedent. In many other countries, a civil law system is in effect. Judgments in these jurisdictions are based strictly on very specific, well-defined laws, codes and regulations—not on precedent. Before doing business in a foreign country, engineers and legal staff should be aware of which approach, common or civil law, is practiced there.

8.4.3 Ensuring that intellectual property is adequately protected

The steps required to protect intellectual property (IP) depends upon the form of the IP asset. Patents, for example, require that applications are filed with the U.S. Patent and Trademark Office. Approval can often take more than a year. Copyright protection, on the other hand, is automatically afforded to the author or artist. To be able to recover funds for copyright infringement, however, registration is required with the U.S. Copyright Office for writings and forms of art. To establish trademark status, all that is required is evidence of the first original use of the mark. The U.S. Patent and Trademark Office, however, does require registration with an appropriate state office to provide notice of the first date of use.

Of special importance for engineers of all disciplines is protecting technological advances. Encourage employees to ensure that their contributions are protected by:

- Establishing and use a recordkeeping system to document all new developments.
- Developing a method of rewarding inventive employees (bonuses, etc.).
- Working in partnership with internal or external patent attorneys.[197]

Develop an intellectual property protection strategy no matter what size the business. Begin by assessing the company's IP assets, and then determine the process for protecting them.

To inventory your IP assets:

- Identify all innovations in products or manufacturing methods developed during the last two years to determine what assets may require patent or trade-secret protection.
- Collect software and published materials from the last five years for potential copyright protection.
- Review logos and product brands to identify assets requiring registered mark protection.[198]

Next, protect the company's trade secrets from competitors, especially for those products and processes that will be difficult to reverse engineer. To do this:

[197] Henry Charmasson, *Patents, Copyrights & Trademarks For Dummies*, Wiley Publishing, Hoboken, NJ, 2004, p. 26.
[198] ibid., p. 22.

- Develop confidentiality agreements.
- Mark certain documents as "confidential" and limit access to them.
- Restrict access to certain areas of the job site.[199]

Finally, no process for protecting intellectual property rights would be complete without a diligent review of competitor's products. Being proactive minimizes the chances of infringement and lawsuits.

Putting It Into Practice: What could you do to better ensure that your company's intellectual properties are being fully protected?

8.5 U.S. and International Codes, Standards, and Regulations

Just as there are many agencies and governmental bodies involved with setting mandatory regulatory codes and standards in the U.S., there are also numerous bodies involved in the creation of voluntary industry standards. One of the most influential is the American National Standards Institute (ANSI) (http://www.ansi.org/).

ANSI is the largest standard-setting organization in the U.S. with more than 10,000 voluntary national standards in its portfolio. ANSI is a private non-profit organization of approximately 1200 members consisting of other member organizations, including trade associations, technical societies, industrial companies, labor organizations, consumer organizations, and governmental agencies.

The ANSI organization itself does not create the standards. Instead, it accredits other organizations and groups to develop them. Typically, the standard is created by a consortium of trade associations, professional societies, or other groups representing the impacted industries.

Through ANSI's searchable database called NSSN (http://www.nssn.org), it is possible to search by document number or keyword for standards of many kinds, including standards by other regional, national, and international standard developers and information found in the Code of Federal Regulations (CFR).[200]

8.5.1 Knowledge of international standards, codes, and regulations

Almost all businesses are increasingly affected by globalization. Globalization makes national boundaries less important and international cooperation much more crucial.

.1 Treaties, Agreements, and Protocols

International treaties, agreements, and protocols are standards to be followed when two or more countries, or persons or organizations from different countries, have dealings with each

[199] ibid., p. 23.

[200] NSSN: A National Resource for Global Standards. Available at http://www.nssn.org.Viewed 08/10/09.

other. Treaties are, by definition, formal agreements negotiated by governments and, therefore, have the effect of law. Agreements and protocols may represent voluntary agreements between non-governmental organizations and may not be as binding, although those who seek to engage in international business usually find it politically and economically wise to follow them.

As indicated in Figure 8-11, there are three kinds of international engineering standards to be aware of as a practicing engineer:

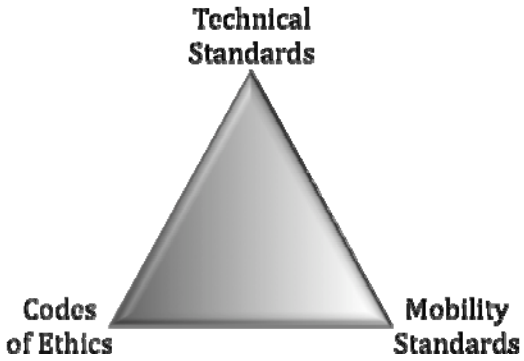

Figure 8- 11 International Standards

.2 International Technical Standards

Some of the leading organizations working on international standards and codes are described below:

International Organization for Standardization (ISO) http://www.iso.org: ISO is perhaps the world's leading developer of international standards. As of March 2005, ISO had a portfolio of more than 15,000 standards, covering diverse topics from manufacturing motorcycles to protecting the water quality of a watershed. ISO is a non-governmental federation of the principal standard-setting entities from about 150 countries, one representative per country. The members suggest what standards are needed and then provide assistance in creating them. After a standard is developed, it is assumed that at least some nations will also adopt it as a national standard.[201]

International Electro-technical Commission (IEC)
http://www.iec.ch/about/mission-e.htm: IEC develops international standards in the field of electrical, electronic, and related technologies. IEC standards are widely adopted as the basis of national or regional electro-technical standards, and are often quoted in manufacturers' specifications and by users when calling for tenders. The IEC's present membership of 51 countries includes most major trading nations.[202]

International Telecommunication Union (ITU-T)
http://www.itu.int/home/index.html: ITU-T works with ISO, governments, and the private

[201] "ISO in Brief: International Standards for a sustainable world." Available at http://www.iso.org/iso/en/ISOOnline.frontpage. Viewed 08/10/09.

[202] About the IEC. Available at http://www.iec.ch/about/mission-e.htm. Viewed 08/10/09.

sector to coordinate global telecom networks and publishes international standards for the telecom industry.[203]

World Trade Organization (WTO)
http://www.wto.org/: WTO addresses the rules of international and global trade.[204]

International Code Council (ICC)
http://www.iccsafe.org/: ICC is a nonprofit organization dedicated to developing a single set of comprehensive and coordinated national construction codes. The founders of ICC are Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International, Inc. (SBCCI).

In addition to organizations focused on developing international standards, many countries have their own standards-setting organizations to address national codes. Engineers doing business in those countries should become familiar with these organizations and the standards set by them.

Putting It Into Practice: What are your best sources for information about international standards?

.3 International Mobility Standards

In order to practice or operate globally, many individuals and organizations require standards and procedures that make it easier for them to work in and travel between different countries (see Figure 8-12). Professional societies, organizations and governments are taking the lead in the creation of such mobility standards.

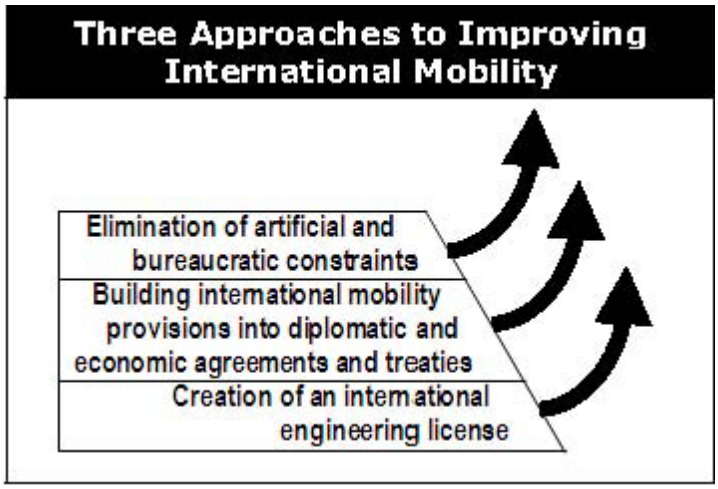

Figure 8- 12 Improving International Mobility

[203] Welcome to the International Telecommunication Union. Available at http://www.itu.int/home/index.html. Viewed 08/10/09.

[204] Welcome to the WTO Website: Available at http://www.wto.org/. Viewed 08/10/09.

Removal of Mobility Constraints: The United States Council for International Engineering Practice (USCIEP) works to develop and promote procedures that would enable U.S.-registered engineers to practice internationally. The Council seeks to identify and eliminate constraints to cross-border practice and negotiate and recommend tentative agreements that will allow such practice.[205]

Mobility Via Treaty: The North American Free Trade Agreement (NAFTA), passed in 1994, is a comprehensive free trade agreement between the United States, Canada, Mexico, and the World Trade Organization. NAFTA provides for reciprocal licensing of engineers from the three.[206]

The General Agreement on Trade in Services (GATS) was enacted in January 1995 by the World Trade Organization (WTO). GATS now calls for more than 135 WTO members to facilitate international mobility.[207]

International Licensure: The development of a widely-accepted international engineer's license would enhance international mobility for engineers. Currently, Engineering Credentials Evaluation International (ECEI) evaluates the engineering credentials of engineers from outside the United States.[208]This service can be helpful to U.S. companies wanting to hire qualified engineers from outside the country, whether the hires are for stateside or international work.

.3 International Codes of Ethics

Given the wide variety of cultural differences around the world, it might appear that developing an international *code of ethics* for engineers would be a daunting task. Various professional societies within the engineering profession, however, have already created examples of such codes. An especially encouraging sign is the code of ethics developed for work under the NAFTA treaty.[209] The World Federation of Engineering Organizations (WFEO) has also created a model code of ethics at http://www.unesco.org/wfeo/ethics.html that is to be used by organizational members of the Federation.[210]

The central tenet of these codes dictates that when engineers practice or work in an international context, they must respect local cultures and regulations. In addition, they should avoid the presumption of their own moral superiority or inferiority, and be cognizant that the laws and ethics of their home country do not necessarily apply in other nations. Contact local organizations governing professional practice for information and guidance.

---

[205] What is ICIEP? Available at http://www.wfeo.org/index.php?page=ethics. Viewed 08/10/09.

[206] E. L. Wust, "The Effects of Globalization on the Civil Engineering Profession." Paper prepared for the Conference on International Services Learning Programs, Marquette University, March 28-29, 2003. Available at http://www.marquette.edu/servicelearning/conference/example_pap.pdf. Viewed 08/10/09.

[207] ibid.

[208] About ECEI. Engineering Credentials Evaluation International (ECEI). Available at http://www.ecei.org/. Viewed 08/10/09.

[209] "Conduct and Ethics in Engineering Practice Related to the North American Free Trade Agreement." Final Report to the National Science Foundation. Murdough Center for Engineering Professionalism. Texas Tech University. Available at http://www.murdough.ttu.edu//Nafta_Report.htm. Viewed 08/10/09.

[210] The WFEO Model Code of Ethics. World Federation of Engineering Organizations. Available at http://www.wfeo.org/index.php?page=ethics. Viewed 08/10/09.

8.5.2 Knowledge of U.S. standards, codes, and regulations for working with international companies (non-U.S.)

When working with international companies, managers must be very aware of the correlations and differences between U.S. and international standards. This is particularly important because of the higher cost associated with loss-of-product for international non-compliance.

.1 U.S. Standards for Working With International Companies

For engineers dealing with overseas companies and international issues, many of the standards, international and U.S., mentioned in the last few pages might be relevant. Whether a standard is relevant depends on the location of the work and whether the international company is going to be sharing a project on U.S. soil or the U.S. Company is going overseas to work. Certainly, the technical standards of ISO and ANSI may be involved. Provisions of the NAFTA and GATS agreements may apply in relationship to both products and services. If the work is done in the U.S., all U.S. laws and regulations would apply.

Regulations related to foreign worker entry, worker permits, and immigration must be addressed whether the employer is from the U.S. or from another country. United States federal travel advisories or prohibitions must be observed; and if there are no travel prohibitions, passport, visa, and immigration rules still must be obeyed. Regulations regarding earnings overseas and U.S. (or foreign) income taxes must be followed. Questions about withholdings from salary or wages must be addressed, from the point of view of both countries, as well as questions of healthcare coverage while the foreign worker is in the U.S. The worker must understand what their status as a foreigner means and what requirements (U.S. and foreign) that status entails. NAFTA and/or GATS and any such negotiated agreements would apply if the country is a signatory to those agreements. Contact information about the nearest U.S. embassy or consulate should always be available.

8.5.3 Applying standards to international engineering projects

Prior to the initiating the design phase of an international project, the engineering manager should acquire the standards from each applicable county. Once in hand, he or she will be able to determine whether, given the different standards of each country involved, the proposed activity is feasible or even desirable. To gather and assess these standards, engineering managers should take the following steps:

- Determine what standards will apply
- Acquire copies of the standards and codes
- Ensure that all standards are updated
- Communicate updated regulations to all employees who require the knowledge
- Interpret the standard — seeking out expert assistance, if needed
- Take extra care to ensure all parties involved have exactly similar of the standards

When working in multinational teams, communication is critical. Even if team members are fluent in a common language, the likelihood of misunderstandings and communication errors is high. Experts advise:

- Agree on a single language to be used for communications.
- Whenever possible, communicate in writing.
- Agree on metric standards to be used (for example: the metric system, English system, etc.).
- Remember cultural differences and respect diversity.
- Become familiar with the expectations and customs of the country(s) you are working with.

Communicate frequently. Take care to confirm understanding of what international team members are saying (for example: confirming times for teleconferences when individuals are in different time zones).

.1 Finding Information Needed to Apply Technical Standards

In order to ensure that international projects are successful and that standards can be applied, find out as much about the local situation as possible. This inquiry must be conducted before the design procedures begin — especially if the project locale is in a rural area or in a less-developed countries.

Completing a project will be especially challenging without the necessary resources — human, mechanical, electrical, electronic, etc. immediately after the breakup of the Soviet Union, for example, electric power was only available in some eastern European countries for a few hours per day. In some instances, the power grids and the telephone lines did not operate at the same time; phone calls were made and received in the dark.

Consider the following questions when analyzing local conditions as they relate to available resources and a project's technical requirements.

Human Resources: What are the characteristics of the local labor force? What are their skills? How many workers are available? What cultural norms will influence their work?

Electrical/Mechanical: What are the local power sources? How easily are they accessed? What are the voltages? Are there frequent power outages? What are the local mechanical support resources? Are parts/components readily available?

Communication/Transportation: Is there high speed internet access? Will cell phones in general and/or the company's cell phones in particular, work in the area? Where is the closest public or usable phone? What are transportation options in the area? How reliable are they? Where is the nearest gasoline/petrol station or source?

Facilities/Accommodations: What are the characteristics of the facility you will be operating in? Does the environment meet your requirements? What are building codes in the area? What will living conditions be like for staff? Will running water be available 24 hours a day?

Cultural Specifics: What kind of clothing is considered acceptable? What is the day of rest? How are "good manners" different there? For example, in many cultures, the jovial slap on the back or squeeze of the shoulder is not polite and touching the head is absolutely insulting. What rituals are considered necessary and polite at a dinner party? At a business meeting?

When working on an international project, some of the most important standards to be concerned with are the standards of behavior. Obtaining the answers to these and other questions impacts project planning, as well as the ability to meet deadlines and achieve a number of quality, safety, environmental, production and other standards.

Putting It Into Practice: Where would you go to collect information on international work sites? How would you document the data you collect?

.2 Getting Help

It is always useful to have a staff member with experience in the area, especially someone who speaks the language. If a translator is needed, try to get realistic recommendations, perhaps from other U.S. companies in the area or a college or university, particularly if the school has an engineering program.

Consider enlisting assistance from some advisor or go-between from the actual locale of any project. There may be companies in the project area with which to form temporary partnerships. Handle such partnerships with care as the ethics, business culture, and/or social expectations of the partner company or consultant might be very different from your own. If need be, the diplomatic network may be accessed via consulates.

There are also resources within the profession who can provide advice throughout the project. These include:

- The World Federation of Engineering Organizations (WFEO) (http://www.wfeo.org) offers advice and assistance in matters related to international engineering efforts. The website provides names, addresses, and phone numbers of the members, which are accessed by choosing the country of interest.[211]

- The United States Council for International Engineering Practice (USCIEP) (http://www.usciep.org) promotes cross-border engineering practice and ease of business restraints.[212]

- Tourist bureaus, local chambers of commerce (or equivalents), and local municipal offices might also prove helpful.

8.6 Professional Codes of Ethics; Professional Liability

In light of the important social function that engineering serves, engineering professionals have always held themselves to a high ethical standard

Ethics address what behavior is considered right and wrong, good and bad — what a person should and should not do. Ethics is not about law per se, although many behaviors that are illegal are also unethical. Many unethical behaviors are forbidden by law, but other unethical behaviors are perfectly legal. Several organizations, including professional societies, create

[211] World Federation of Engineering Organisations (WFEO). Available at http://www.wfeo.org .Viewed 08/10/09.
[212] United States Council for International Engineering Practice (USCIEP). Available at http://www.usciep.org. Viewed 08/10/09.

codes of ethics to help members develop the ability to make effective ethical decisions and follow them up with ethical actions.

An example of a common ethical issue is conflict of interest. Conflict of interest is a common professional practice, but one that's not very easy to confront legally. Some professionals don't even recognize when they are in situation that poses a conflict of interest. An education in ethics and professional orientation is necessary to alleviate the majority of problems related to this issue as well as other ethical concerns.

8.6.1 Knowledge of Professional Ethical Standards and Corporate Codes

Recent business scandals have challenged the public's trust and faith in business leadership and organizational integrity. Consequently, it is more critical than ever that managers act as ethical leaders, holding themselves and their organizations to the highest ethical and professional standards. This means remaining constantly vigilant that they and their staffs are in compliance with all applicable codes and standards.

The Enron scandal was certainly shocking in terms of the amount of money involved and the apparent arrogance of the company officials involved. Other large and previously respected businesses and government officials have been revealed to have engaged in practices that are, at the very least, of questionable ethics and possibly are illegal.

Individuals who are determined to behave ethically face challenges at the workplace (i.e., when an employee's ethical behavior or decision is not in line with company's profitable course of action, the management is not generally supportive of that employee). Having well-conceived company codes of behavior or ethics can provide much needed clarity and guidance to employees when behavioral or ethical issues arise. In this respect, codes of ethics and standards for good behavior may be more important than ever before.

.1 Codes of Ethics Are Important Services of the Engineering Societies

One of the more important services provided by the professional engineering societies is the creation, updating, and promotion of professional codes of ethics. These codes are usually created by committees or councils comprised of members who are active in the profession, and as a result, are often very practical.

While each society or organization's code is unique, there are elements common to each. . For example, in the codes of ethics for the American Society of Mechanical Engineers (ASME), the National Society of Professional Engineers (NSPE), and the American Society of Civil Engineers (ASCE), all stress that engineers first consider the safety, health, and welfare of the public. Also common to all engineering codes of ethics are statements calling engineers to uphold the honor and integrity of their profession and to perform service only in their areas of competence.

Additional Examples of Codes of Ethics

American Society of Mechanical Engineers (ASME) [213]
http://www.asme.org/Education/PreCollege/TeacherResources/Code_Ethics_Engi neers.cfm

Institute of Electrical and Electronics Engineers (IEEE)[214]
http://www.ieee.org/web/membership/ethics/code_ethics.html

The Center for the Study of Ethics in Professions at Illinois Institute of Technology (IIT)[215]
http://ethics.iit.edu/codes/engineer.html
An online library of codes of ethics in the engineering profession

The Online Ethics Center for Engineering and Science at Case Western Reserve University[216]
http://onlineethics.org/codes/index.html,
Offers some international codes and codes in Spanish.

Putting It Into Practice: What is your personal code of ethics?

8.6.2 Applying and enforcing standards when dealing with ethical or professional liability issues involving direct reports

Experts agree that upper management has a great deal of influence on the attitudes and behaviors of their employees, and subsequently, must lead by example. All managers, whether a corporate level executive or a line supervisor, must not only expect high standards of behavior from their staffs, but must also "walk the talk."

Management must also hold staff members immediately accountable for their actions, whether positive or negative. They must be willing to back up these standards of behaviors with rewards and money for programs and, if need be, punishment for wrongdoing.

There are several reasons why ethics, and the protocols and procedures they prescribe, might be overlooked or ignored. They are represented in Figure 8-13.

.1 Ethics Training

Sometimes individuals do not see that a situation has ethical implications even if they are familiar with the codes of ethics or behavioral guidelines. Or, if they recognize the ethical problem, they don't know how to apply the guidelines. Ethics training enables employees to recognize ethical problems and learn how to think them through to a best solution. Offering training in a variety of modes, like providing professional development courses, requesting

---

[213] Code of Ethics of Engineers. Available at http://www.asme.org/Education/PreCollege/TeacherResources/Code_Ethics_Engineers.cfm. Viewed 08/10/09.

[214] Guidelines for Engineers Dissenting on Ethical Grounds. The Online Ethics Center for Engineering and Science at Case Western Reserve University. Created 1996 by IEEE Ethics Committee. Available at http://www.ieee.org/web/aboutus/ethics/dissent.xml. Viewed 08/10/09.

[215] Codes of Ethics Online/Engineering. Center for the Study of Ethics in the Professions. Illinois Institute of Technology. Available at http://ethics.iit.edu/codes/engineer.html. Viewed 08/10/09.

[216] Codes of Ethics and Conduct. The Online Ethics Center for Engineering and Science at Case Western Reserve University. Available at http://onlineethics.org/codes/index.html#codeoec. Viewed 08/10/09.

professional registration, on the job training by taking an actual situation at hand and demonstrating how to deal with it, as well as including ongoing follow-up from a supervisor is probably best.

Although we think of ethics as the study of right and wrong, the truth is that many decisions that have ethical overtones are not clearly black or white. Sometimes the only possible answers all feel wrong, because no matter what answer is chosen, someone is going to be hurt, angry, or disadvantaged in some way. Ethics training, particularly using discussion and case studies, can help people recognize ethics problems and learn how to think them through.

Problems	Solutions
Some employees are unfamiliar with codes of ethics or behavior guidelines. Sometimes people are unaware of the ethical codes or behavioral guidelines that they should be guided by. Or, they don't see how these ethics apply to situations they are in. They don't think far enough ahead to see that not doing something they are supposed to do or doing something they are not supposed to have done can result in extremely negative consequences — for the individual and the organization.	• Organizational management needs to make sure that employees are made aware of rules and guidelines for behavior. • Direct engineers to whichever professional code is appropriate — show actual codes, so that staff become familiar with the style and format used. • Participate in professional societies that create and promote ethical codes. • Distribute copies of company and industry codes of ethics. • Create a structure for employees to commit themselves in writing to the established ethical standards and corporate codes. • Offer or require periodic (e.g., annual) training in professional ethics.
Employees are tempted and/or pressured to behave unethically.	• Make codes of ethics public and a priority. Public pledges to follow codes may act as a sort of shield to support employee's ability to resist pressure or temptation. • Create structures for employees facing ethical dilemmas to discuss issues with an informed and impartial third party. • Establish resources and procedures for employees who feel unduly influenced.
Staff perceives that organization leadership is not committed to ethical actions.	• Demonstrate management's commitment to code of ethics. • Respond swiftly and publicly to infractions in ethical policy. • Make communicating commitment to ethics a priority.

Figure 8- 13 Ethical Problems and Solutions

.2 Resisting the Dangers of Corporate Think

Another possible obstacle to ethical decision making in engineering is "corporate think." Corporate think involves ideas such as "The bottom line rules" and "It has to be done yesterday" and "The boss is always right, even when he's wrong."

This can lead to tragic consequences, such as the 1986 Challenger disaster. Several engineers-turned-managers from Morton-Thiokol decided that they had to "put on their management hats" and begin thinking like managers, which meant allowing the Challenger to launch on schedule, despite the fact that they had received a unanimous recommendation from their engineering staff that a launch at that time could be too dangerous. All seven Challenger crew members died when the space shuttle exploded.[217]

Engineers and managers must learn how to come to agreements that do not violate ethical codes or standards that affect the safety of anyone or that put the company at unusually high liability risk. One way to achieve this goal involves eliminating obstacles to ethical decision making (see Figure 8-14).

Obstacles to Ethical Decision Making: Rationalizations

1. If it's necessary, it's ethical.
2. "The False Necessity Trap"
3. If it's legal and permissible, it's proper
4. It's just part of the job
5. It's all for a good cause
6. I was just doing it for you
7. I'm just fighting fire with fire
8. It doesn't hurt anyone
9. Everyone's doing it
10. It's OK if I don't gain personally
11. I've got it coming
12. I can still be objective

Figure 8- 14 Obstacles to Ethical Decision Making: Rationalizations[218]

Putting It Into Practice: What phrases listed above have you used? How will you respond in the future?

[217] Vivian Weil and Michael Davis, "Professional Ethics at the Interface of Engineering and Management." Perspectives on the Professions. Center for the Study of Ethics in the Professions. Illinois Institute of Technology. Reprint from Spring 1987. Available at http://ethics.iit.edu/perspective/pers7_1spr87_2.html. Viewed 08/10/09.

[218] Josephson, Michael. *Making Ethical Decisions.* The Josephson Institute of Ethics, 2002, pp. 27-28.

8.6.3 Applying and enforcing standards when dealing with ethical or professional liability issues in international engineering projects

Enforcing standards and ethical decisions is more complicated when doing business internationally. International laws vary, so it is important to carefully research the legal policies and practices in the country where business will occur. Consulting the appropriate advisors can literally save millions of dollars.

Cultural differences need to be accounted for, especially the nuanced differences between cultural, ethical, and liability beliefs and practices. Choice of words used (or not used) to express needs, wants, or project requirements is often critical to the success of a venture. Liability issues are closely tied to expectations. From the outset, clearly defined project boundaries and descriptions of requirements, objectives, purpose and desired outcome reduce liability risk. Meeting standards and following regulations is critical in any business environment. In international projects it is wise to create priorities and distinguish which standards may be more critical than others. Do not assume. The United Nations (http://www.un.org/law) assists with research in these areas.

Leading U.S. companies increasingly recognize that, to succeed abroad, they must join together with like-minded companies to influence laws, rules, and policies that may undermine U.S. competitiveness, wherever they may be. The United States Council for International Business (www.uscib.org) helps companies do just that. It gives business a seat at the table on a wide range of issues — from environment to e-commerce to labor relations. It presents U.S. business ideas, values, and solutions directly to U.S. policy-makers and officials in the United Nations, European Union, and a host of other governments and groups.

Moreover, USCIB works on a variety of fronts to smooth the way for U.S. commerce abroad, promoting practical business services such as international commercial arbitration to resolve disputes swiftly. When an issue, conflict, or opportunity arises, USCIB members know which doors to knock on to safeguard their interests and ensure a more open, free, and fair international marketplace.

.1 Multilateral Environmental Agreements With Liability Provisions

Environmental issues are a hot topic on the international scene. There are a number of multilateral environmental agreements (MEAs) that include provisions for liability regimes. The U.S. government is a nonparty to many MEAs; however, there is an expansion of lawsuits in U.S. courts seeking compensation from U.S. companies for environmental damage occurring outside the U.S. As negotiations unfold, many details will have to be worked out including: what scope of activities/damages will be covered, how environmental damage will be defined, whether the liability will be fault-based or strict, how the burden of proof will be determined, and whether there will be payment caps.

Review

Upon completing the study of *Domain 8: Professional Responsibility, Ethics and Legal Issues,* you will be able to answer the following questions.

1. List four types of procedure documents that engineers work with.
2. Why is it important to carefully follow procedure documentation?
3. How are regulatory standards developed? By whom and for what purpose?
4. Describe the process by which most industry standards are developed. Be sure to discuss who develops the standards and why.
5. Imagine that you are developing a new product (in the United States) and need to ensure that your standards information is current. Where could you go to update standards?
6. Identify five actions you, as a manager, can take to promote staff compliance to standards.
7. What are the three types of intellectual property? Describe the basic characteristics of each.
8. Discuss at least three ways in which working with international contracts and standards differs from domestic contract and standards management.
9. What should engineering managers do to protect the intellectual property they are responsible for at their place of business?
10. What are professional associations and government agencies doing to improve international mobility for engineers?
11. What help would you enlist when facing challenges in understanding and meeting standards for an international project?
12. What are the benefits of using a carefully crafted code of ethics in the workplace?
13. Identify three obstacles to ethical decision making that you have observed at work. What would you do to overcome each to the obstacles?

For Further Information

- http://www.bizmanualz/com--Bizmanualz offers a wide variety of software packages with templates to simplify the process of documenting a wide variety of procedures.
- *Writing Effective Policies and Procedures* by Nancy Campbell is a straightforward resource addressing the topic generally. It does specifically address *engineering* documentation.
- *http:www.aaes.org/international/index.asp* – The International section of the American Association of Engineering Societies has information available about international organizations that might be helpful to engineers.
- *http://www.theiet.org* -- The Institution of Engineering and Technology (IET) (a merger of the IEE and IIE), offers a course in contract law designed specifically for engineers.
- *Defining Moments: When Managers Must Choose between Right and Right* by Joseph Badaracco is a thought-provoking book on business ethics.

Common Acronyms

ABB	Activity-Based Budgeting
ACSI	American Customer Satisfaction Index
ADA	Americans With Disabilities Act
ADEA	Age Discrimination in Employment Act of 1967
AI	Appreciative Inquiry
AMA	American Management Association
ANSI	American National Standards Institute
APS	Advanced Planning and Scheduling
ASAP	Association of Strategic Alliance Professionals
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASSIST	Acquisition Streamlining and Standardization Information System
B2B	Business-to-Business B2C Business-to-Customer
BATNA	Best Alternative to a Negotiated Agreement
BCBP	Bar-Coded Boarding Pass
BOCA	Building Officials and Code Administrators International
BSI	British Standards Institution
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CETA	Controlled Environment Testing Association
CFD	Computational Fluid Dynamics
CFD	Cash Flow Diagrams
CFR	Code of Federal Regulations
CI	Competitive Intelligence
CIM	Computer Integrated Manufacturing

CIP	Competitive Intelligence Programs
COP	Certified Outsourcing Professional
CPSC	Consumer Product Safety Commission
CRM	Customer Relationship Management
CSA	Canadian Standards Association
CSG	Council of State Governments
CUSS	Common User Self-Service Kiosks
DBE	Disadvantaged Business Enterprise
DCF	Discounted Cash Flow
ECEI	Engineering Credentials Evaluation International
EEO	Equal Employment Opportunity
EEOC	Equal Employment Opportunity Commission
EIA	Electronic Industries Alliance
EPA	Environmental Protection Agency
EPA	Equal Pay Act of 1963
ERP	Enterprise Resource Planning
IET	Interline Electronic Ticketing
EVA	Economic Value Added
FDA	Food and Drug Administration
FEA	Finite Element Analysis
FEM	Finite Element Modeling
WFEO	World Federation of Engineering Organizations
FITA	Federation of International Trade Associations
FMEA	Failure Mode and Effect Analysis
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
GMP	Good Manufacturing Practices

HP	Hewlett Packard
HR	Human Resources
IAOP	International Association for Outsourcing Professionals
IAPMO	International Association of Plumbing and Mechanical Officials
IATA	International Air Transport Association
ICBO	International Conference of Building Officials
ICC	International Code Council
IEE	Institution of Electrical Engineers
IEEE	Institute of Electrical and Electronic Engineers
IET	Institution of Engineering and Technology
IIE	Institution of Incorporated Engineers
IIT	Illinois Institute of Technology
IRR	Internal Rate of Return
ISO	International Organization for Standardization
IT	Information Technology
ITA	International Trade Administration
ITU	International Telecommunications Union
IW	Industry Week (Magazine)
JIT	Just-in-Time
KPI	Key Performance Indicators
MARR	Minimum Attractive Rate of Return
MEAs	Multilateral Environmental Agreements
MES	Manufacturing Execution System
MIT	Massachusetts Institute of Technology
MRP	Materials Resource Planning
MRPII	Manufacturing Resource Planning
NAFTA	North American Free Trade Agreement

NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPR	Net Present Return
NPV	Net Present Value
NSPE	National Society of Professional Engineers
NSSN	National Standards System Network
OCR	Optical Character Recognition
OSHA	Occupational Safety and Health Administration
P&Ls	Profit and Loss
PDF	Portable Document Format
PDM	Product Data Management
PDPC	Process Decision Program Chart
PEST	Political, Economic, Social, and Technological
PM	Project Management
PMI	Project Management Institute
PPE	Personal Protective Equipment
PR	Public Relations
QFD	Quality Function Deployment
QS9000	Quality System Requirements of the Automotive Industry
R&D	Research and Development
RCM	Reliability Centered Maintenance
RFID	Radio Frequency Identification
RFP	Request for Proposal
ROI	Return on Investment
SBCCI	Southern Building Code Congress International, Inc
SCM	Supply Chain Management
SPC	Statistical Process Control

StB	Simplifying the Business
StB PP	Simplifying the Business Preferred Partner
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TQM	Total Quality Management
Ts & Cs	Terms and Conditions
UCF	Uniform Contract Format
UCF	Uniform Contract Format
USCIB	United States Council for International Business
USCIEP	United States Council for International Engineering Practice
USP	Unique Selling Proposition
VAF	Value Adjustment Factor
WACC	Weighted Average Cost of Capital
WFEO	World Federation of Engineering Organizations
WIPO	World Intellectual Property Organization
WMS	Warehouse Management Systems
WTO	World Trade Organization
ZBB	Zero-Based Budgeting

Glossary

Note: Terms used in definitions that are also defined in the glossary are indicated in *italics* the first time they appear in any definition. Multiple glossary terms may be included in a series.

Advertising. Mass media communications of a specific message (or set of messages) to potential buyers

Balance Sheet. A statement of company resources at a given point in time in terms of assets, liabilities, and owner's equity

Balanced Scorecard. A measurement and management system that seeks to link financial data and strategic planning activities

Benchmarking. The process of improving performance by continuously identifying, understanding, and adapting the best practices and processes found inside and outside the organization

Black Belt. Person who will lead a Six Sigma quality improvement team as his or her full-time job

Boston Matrix. Model used to describe a product in relationship to its levels in market share and market growth

Branding. Establishing a product "identity" that customers associate with various product qualities (quality, price, service, image, etc.) and which creates value in customers' minds

Business Forecasting. A means of measuring economic conditions using statistical models to predict the potential market attractiveness and the organization's competitive position factors at a future time

Cash Flow Analysis. Study of the cycle of cash inflow and outflow in a business

Change Drivers. Events or variables that drive the evolution of industries

Code of Ethics. Code outlining what is ethical behavior for persons in a profession — usually developed by a professional membership organization

Code. Related groups of standards usually created by experts in the particular field and then adopted by governmental bodies

Compensation. Items earned by the employee for the job that they do such as salary, benefits package, bonuses and rewards

Competitive Intelligence Audit. A review of an organization's operations to determine what is actually known about the competitors and their operations

Conflict Mediation. The processes of assisting disputants in defining a conflict and searching for ways to reduce or eliminate it

Copyright. The exclusive legal right to reproduce, publish, and sell original work created by a writer (e.g., computer software, literary works, artistic works, etc.)

Cost of Capital. Actual cost of the capital project plus the opportunity costs associated with the investment

Cycle Time Analysis. Analysis that helps to strike a balance between factory loading and cycle time

Data Flow Diagram. Linear representation of a system

Decision Table. A chart listing all logical conditions and actions

Decision Tree. Defines conditions as a series of left-to-right tests showing all possible paths in a design

DMAIC. Quality strategy that is part of the Six Sigma quality initiative

Earned Value Analysis. A way to assess a project's progress, forecast completion date and final cost, and provide schedule and budget variance along the way

EEOC Regulations. The regulations set by the U. S. Equal Employment Opportunity Commission to ensure fair employment practices are extended to all employees and potential employees regardless of diversity factors

Enterprise Resource Planning (ERP). Software applications designed to integrate company information and automate as many basic functions as possible

Finite Element Analysis. A design decision making tool, used to ensure that products are cost effective, safe, and can be brought to market in a timely manner

Flow Chart. A diagram of the various steps involved in designing a system

Green Belt. Person who will lead a Six Sigma process improvement team as part of his or her full-time job

Hygienes. Term coined by Frederick Herzberg to describe certain workplace factors that, alone, are unlikely to increase worker satisfaction or productivity. These include company policy, working conditions, peers, supervisors and pay.

Income Statement/P&Ls. An activity-oriented financial statement that covers a specific period of time and summarizes company revenues and expenses

Internal Rate of Return. The return that a company would realize if it invested in itself or expanded, rather than investing elsewhere

Just In Time (JIT). A supply chain management approach designed to reduce inventories and increase speed of materials purchasing

Kaizan. Gradual, unending improvement and increasingly higher standards

Kaizen. *See* Kaizan

Kaizenshiro. *See* Kaizan

Key Performance Indicators. Quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organization

Lean Manufacturing. An initiative that focuses on elimination of all waste in manufacturing processes

Linking Pin. A role of middle managers used to achieve coordination, inspire cooperation and manage conflict between upper management and direct reports

Market Analysis Report. A formal document used to record the findings of a market analysis, formulate recommendations and share findings with key stakeholders

Market Analysis. The collection of information used to identify and define market opportunities and problems, and to generate, refine and evaluate market options

Market Segmentation. Dividing the market base into homogenous groups in order to strategically target market activities

Marketing. Strategies and activities that focus on assessing the needs and wants of potential customers and then meeting those needs

Motivating. To inspire employees to achieve greater productivity

Negotiation. To confer with others in a way that brings about the equitable settlement of a matter

Net Present Value (NPV). A calculation of the present value of cash inflows and the present value of cash outflows used to determine whether an investment or project is profitable

Net Present Value. Analysis used by engineers during capital budgeting to determine whether or not a project should be undertaken

Outsourcing. Engaging the services of third party service providers to add value to the company (streamline operations, reduce costs, reduce time to market, etc.)

Patent. The exclusive legal right to make, sell, or license novel and useful inventions

Performance Feedback. The return of information to employees about the result of a process or activity

Performance Management. The activity of tracking performance against targets and identifying opportunities for improvement

Poke-a-Yoke. Mistake proofing or error proofing a process

Presentation Techniques. Oral and written communications methods to assist in a focused expression of ideas, recommendations and findings used to inform and influence the thinking of others

Product Life Cycle. The stages that products progress through from development to withdrawal from the market

Product Portfolio. The range of products a company has in development or available for consumers at any one time

Recruitment. The process of locating new team members whose knowledge, skills and abilities fit the needs of the team

Regulation. Rule formulated and issued by a governmental agency — typically has the force of law

Return on Investment (ROI). A calculation which identifies profits to be realized or costs to be saved from implementing a project

Risk Analysis. A formal framework to identify what actions to take to avoid disruption of marketing plans. Risk equals the probability of an event times the cost of the event

Risk Register. A progressive document used over time that contains the outcomes of all risk management processes throughout the lifecycle of the marketing project

Sales. Strategies and activities that focus on the attempt to motivate potential customers to purchase a product or service

Selection. The process of establishing selection criteria, interviewing and hiring the most qualified job applicant

Simulation. Evaluation tool formulated by creating hypothesis about what will happen in the future based on the input of different sets of variables

Six Sigma. A tool to improve the processes of a business characterized by well-defined projects executed by a team that includes management champions, Black Belts, and Green Belts

Standard. A description established by authority, custom, or general consent as a model of performance, quality, etc.; also, an established rule of measurement

SWOT Analysis. An analysis that identifies the strengths, weaknesses, opportunities, and threats a project faces

Team Dynamics. The motivating and driving forces that propel a team towards its goal or mission

Technology Assessment. An assessment process used to determine the capabilities of any given technology including its specifications and performance, and applicability to a planned project

Terms and Conditions. The various clauses that collectively make up a contract

Total Quality Management. A management approach to long-term quality improvement by including the entire organization in the improvement process

Trademark. The exclusive legal right to use and identifying mark (logo, symbol, product name) as long as it is kept in use.

Training and Development. The design and delivery of workplace learning to improve performance

Trend Analysis. A process that uses historical data to examine what has happened in an organization's past to assist in predicting what might occur in the future

Uniform Contract format (UCF). A template of standard contract elements to use when creating engineering contracts

Weighted Average Cost of Capital. Described by the formula: (1 minus debt to capital ratio) * cost of equity + debt to capital ratio * cost of debt

Work Breakdown Structure. Process that identifies all tasks required to complete a project, the order in which they must occur, the materials required, and the costs associated with each task

Workforce Diversity. Using inclusion as a means of achieving superior performance by recognizing the unique contributions of each employee towards meeting the company's goals

Index

A

action plans, 18, 65, 68, 69, 70, 74, 75, 116, 236, 357
Activity-Based Budgeting, 207, 381
advertising
  plan, 15, 21, 227, 232
  process, 229–31
ANSI (American National Standards Institute), 20, 63, 157, 178, 355, 368, 372, 381
ASME (American Society for Mechanical Engineers), viii, ix, 13, 171, 350, 355, 365, 375, 376, 381

B

balance sheet, 15, 20, 191, 211, 212, 213, 225
balanced scorecard, 218, 225
benchmarking, 14, 36, 37, 41, 72, 74, 266
  applying best practices, 35–37
  process, 35–37
best practices, 35, 37
Boston Matrix, 228, 247, 248, 251, 265, 387
bracket budgeting, 207
branding, 228, 238, 245, 246, 247, 387
budget
  alternatives, 206–8
  process, 163
  techniques, 204–8
business plan
  elements, 210–11
  evaluation, 212
  financial, 210–11

C

CAD (computer aided design), 48, 49, 129, 139, 381
CAM (computer aided manufacturing), 48, 49, 139, 381
capital, 21, 94, 158, 159, 160, 161, 164, 191, 201, 213, 217, 385, 387, 390
  budget, 189
  resource requirements, 21, 164, 191
cash flow
  analysis, 160
  diagrams, 208, 381
  schedules, 209
  techniques, 208–10
change management
  conflict, 118
  process dynamics, 117
  resistance, 119
  team performance, 119–22
  techniques, 117–22
change orders, 168
code of ethics
  enforcing, 376–79
  engineering, 375–76
  international, 378–79
  professional, 374–79
communication
  conflict resolution, 337–41
  disagreement, 61
  listening, 60
  multimedia, 55
  oral, 57
  presesntations, 54–61
  process, 57
  visual aids, 59
  written, 56
compensation, 268
Compensation, 328, 329, 387
conflict resolution
  mediation, 339–41
  phases, 338
  resolving, 338–41
contract
  communication, 200
  documentation, 194
  international, 366
  interpretation, 198
  law, 364
  legal requirements, 193
  management, 199, 366
  preparation, 197
  procedures, 201
  types, 196
  Uniform Contract Format, 195
  workers, 201
cost estimation, 219–21
critical path, 132, 166, 168, 170, 173, 174, 180
customer
  feedback, 20, 144, 157, 174, 175, 176, 189, 245
  needs, 20, 34, 46, 68, 80, 106, 157, 176, 181, 243
  satisfaction, 15, 21, 84, 141, 174, 175, 176, 227, 234, 235, 236, 237, 265, 266, 357
Customer
  retention, 233
customer satisfaction
  analysis, 236–38
  measurement, 234–36
  surveys and questionnaires, 234–36
cycle time, 35, 224, 342, 388

D

Daily work reports, 194
Deming, W. Edwards, 177
discounted cash flow, 162, 382
Drucker, Peter, 268, 277

E

earned value analysis, 166
economic equivalence, 219
economic value added (EVA), 217, 382
employee
  compensation policies and practices, 329–30
  selection criteria, 332–33
  selection policies and practices, 328–29, 330–31
  selection regulations, 330–31
engineering disciplines, 127–30
engineering economic analysis, 215–21
  application of, 218–19
  calculations, 219–21
  techniques, 215–17
Engineering Management Certification International, viii, ix, x, xi, 12, 13, 14, 16, 350, 382
environment, 13, 14, 19, 23, 46, 58, 71, 82, 83, 85, 103, 118, 119, 125, 131, 132, 133, 134, 142, 145, 149, 150, 153, 170, 171, 176, 184, 189, 201, 240, 260, 268, 271, 272, 273, 276, 277, 293, 303, 312, 314, 318, 322, 336, 337, 354, 357, 373, 379
EPA (Environmental Protection Agency), 169, 193, 351, 355, 357, 382
Equal Employment Opportunity Commission (EEOC), 268, 330, 355, 382, 388
ethics
  in international context, 379
  obstacles, 378
  training, 377

F

financial
  constraints, 203
  plan, 211
finite element analysis, 188, 189, 382
flow chart, 76
forecasting, 14, 17, 27, 38, 39, 41, 46, 47, 48, 49, 62, 63, 188, 209, 222, 243
  NPV (net present value), 216
  ROI (return on investment), 216
  techniques, 40
function point analysis, 184
funding
  government, 202
  proposals, 203–4
  sources, 201–4

H

Herzberg, Frederick, 268, 275, 278, 279, 280, 281, 282, 345, 388
high performance team, 120
hygienes, 268
Hygienes, 275, 281, 282, 303

I

income statement, 213–15
incremental analysis, 217
inflation, 220
integrated management model
  external environment, 85, 103, 271, 272, 322
  internal environment, 271, 272
  management systems, 22, 223, 267, 271, 321, 385
  organization structure, 22, 267, 272, 273, 285, 293
Integrated Management Model, 270–73
intellectual property
  law, 364
  patents, trademarks, and copyrights, 365
  protecting, 367–68
international codes, standards and regulations, 368–71
  applied to engineering projects, 372–74
international operations, 252–60
  challenges, 253
  cross-cultural communication, 258–60
  cross-cultural management, 255–58
  models, 254
  value differences, 256–57
inventory
  control, 221–24
  monitoring, 224
  software, 223
ISO (International Organization for Standardization), 20, 79, 140, 156, 157, 174, 178, 181, 189, 234, 361, 369, 372, 383
ISO 9000, 79, 140, 174, 178, 189, 234

K

Kaizan, 14, 19, 125, 126, 134, 155, 181, 388
knowledge workers, 268
  managing and motivating, 277–82
Knowledge Workers, 22, 267, 277
Koontz, Harold, 269, 273, 344, 345

L

lean manufacturing, 126, 135, 388
life-cycle engineering, 79
Likert, Rensis, 275, 283, 287, 290, 292, 303, 316, 345
  System IV, 287
linking pin, 268
Linking Pin, 286, 316, 388
liquidity, 160, 215

M

Malcolm Baldrige Award, 178
Management Process School, 274–75
managerial grid, 291–92
managing
  cultural differences, 333–37
  diverse workforce, 333–37
  fair practices, 335–36
  mediation, 339–41
  preventing discrimination, 335–36
manufacturability, 130–45

assembly/disassembly procedures, 133
design for, 132
designed experiment, 142
evaluating prototypes, 144
feasibility, 131
feedback, 131
pilot builds, 131
market analysis, 14, 17, 27, 28, 29, 30, 31, 33, 35, 62, 68, 74, 262, 389
market research, 29–35
PEST, 33, 384
process, 29–35
reporting and communication, 34–35
research design, 31–32
SWOT, 18, 33, 41, 65, 69, 85, 385, 390
marketing, 13, 14, 15, 17, 21, 22, 27, 28, 29, 30, 34, 35, 36, 38, 41, 44, 45, 46, 49, 62, 69, 70, 71, 73, 75, 78, 88, 90, 91, 96, 97, 116, 132, 141, 175, 176, 182, 203, 223, 227, 229, 231, 232, 234, 238, 239, 240, 241, 242, 243, 244, 245, 251, 253, 259, 261, 262, 263, 264, 265, 266, 389, 390
branding, 245–47
communications, 244–45
evaluating effectiveness, 242
global, 231
planning, 234
pricing impact, 264
product portfolio analysis, 247–52
techniques, 238–44
Maslow, Abraham, 275, 278, 279, 281, 282, 345
hiearchy of human needs, 279
McClelland, David, 275, 280, 281, 282, 345
nAchievers, 280, 281, 282, 303
naffiliators, 280
McGregor, Douglas, 275, 278, 281, 282, 345
Theory X and Theory Y, 275, 278, 281
mechanistic organization structure, 268
Mintzberg, Henry, 274, 298, 299, 300, 345
motivators, 268
Motivators, 275, 281, 282, 290

N

negotiation, 341–43
determining needs, 342–43
techniques, 341–42
win win, 343
new technologies
design evaluation, 129
financial risk analysis, 114–16
financial risk management, 112–17
not-for-profit, 208
NPV (net present value), 15, 21, 39, 162, 191, 192, 215, 216, 225, 384, 389

O

organic organization structure, 268
OSHA, 193, 355, 356, 357, 359, 384
outsourcing
IAOP (International Association for Outsourcing Professionals), 105, 383
pricing, 109–10
relationships, 110–11
resources, 104–6
stages, 108
strategic, 106
tactical, 106
transformational, 107

P

partnering, 18, 65, 107, 110, 111, 232
planning
alignment model, 70
issue-based planning, 69
scenario planning, 70
strategic planning, 14, 18, 25, 65, 67, 68, 81, 123, 352
presentation skills, 61
hardware and software, 54–55
multimedia, 55–56
process improvement, 20, 35, 84, 88, 126, 134, 138, 208, 353, 358, 388
process map, 130
product
new product checklist, 73
product design
cost analysis, 151
design structure matricies, 147
diagrams, 152
integrated, 147
sequential, 146
simulations, 151–52
web-based tools, 153
product development tools, 132
product portfolio
analysis, 247–52
balance, 248–49
Boston Matrix, 247–48
changes, 251–52
product life cycle, 250–51
product pricing
determining, 262–64
evaluating, 262–64
strategies, 260–62
profit and loss statement (P&L), 213, 215
profitability, 136, 160, 215, 243
project management, 164–72
budget development, 168
contraints, 15, 20, 71, 74, 115, 132, 157, 160, 173, 189, 191, 203, 232, 263, 371
control, 167
environmental risk, 169
failure, 171
financial risk assessment, 168–69
planning, 166, 170–71
resources, 171–72
schedule, 165, 167, 172–74
work breakdown structure, 172–73

Q

qualitative, 31, 44, 74, 206
quality
  management tools, 179
  quality function deployment (QFD), 141, 181, 384
  standards, 178
quality analysis, 136–38
  Six Sigma, 15, 19, 125, 126, 136, 137, 138, 155, 180, 272, 303, 387, 388, 390
  total quality management (TQM), 15, 19, 20, 36, 106, 125, 136, 137, 140, 155, 157, 177, 178, 179, 207, 385
quality function deployment, 141
quantitative, 31, 44, 46, 74, 206

R

regulations
  accessing, 354–57
  government, 354–57
  violations, 361
Research and Development (R&D), 71, 82, 86, 88, 89, 90, 116, 238, 308, 384
return on investment (ROI), 15, 37, 39, 40, 41, 53, 62, 92, 162, 163, 192, 204, 215, 216, 224, 225, 262, 384, 389
risk analysis
  diagrams, 42–44
  management plan, 44
  prioritization, 117
  response planning, 44–45
  risk identification, 41–42
  risk register, 42
  scenarios and simulations, 15, 18, 19, 65, 77, 78, 79, 114, 115, 123, 125, 129, 131, 132, 138, 139, 140, 148, 151, 152, 153, 154, 155, 186, 187, 188, 189, 318
  techniques, 41–42
risk assessment
  project, 168–69
risk management
  new technology, xi, 44, 112, 169, 352
  risk identification, 112
robust design, 143–44
root cause analysis, 181–82

S

safety, 23, 50, 78, 127, 128, 131, 133, 134, 193, 200, 279, 347, 354, 355, 356, 357, 359, 360, 363, 374, 375, 378
sales
  plans, 232–34
sales engineering, 233
schools of management thought, 269, 273
  Behavioral School, 275
  Decision Theory School, 276
  Empirical School, 275
  Human Behavioral School, 275
  Mathematical School, 275
  Scientific Management, 276
  Social Systems School, 275
Schools of Management Thought, 22, 267, 273
Senge, Peter, 122, 269, 304, 305, 308, 311, 312, 314, 318, 327
simulation, 18
  benefits, 187
  computer, 186–88
  finite element analysis (FEA), 188, 382
  finitie element analysis (FEA), 189
  process, 151
  process flow, 132
  statistical analysis, 188
  web-based, 188
Skinner, B. F., 281, 345
softtware
  forecasting, 188
software
  evaluation, 185
  inventory control, 223
  presentation, 55
  project management, 186
  project planning, 132
  simulation, 132
  supply chain management, 223
span of control, 272, 274
standards
  ISO, 20, 140, 156, 157, 178, 181, 361, 369, 372, 383
  ISO 9000, 79, 140, 174, 178, 189, 234
  quality, 178
standards, codes and requirements
  accessing, 354–57, 368–72
  communication, 358
  environmental, 357
  improving adherence to, 363
  internal, 358–59
  international, 368–71
  mobility, 370–71
  monitoring, 360–61
  safety, 354–57
  training, 359
  violations, 361–62
strategic alliance, 103, 106, 156
supply chain management, 221–24
  enterprise resource planning (ERP), 38, 192, 222, 225, 382, 388
  just-in-time (JIT), 21, 181, 191, 192, 221, 225, 383, 388
  materials resource planning (MRP), 221, 222, 225, 384
  software, 223
SWOT, 33, 41, 85, 385, 390
system design, 14, 15, 18, 65, 75, 78, 79, 123
  decision table, 77
  simulation elements, 78–79
  simulation tools, 77
  system design tools, 75–78
systems thinking, 269
Systems Thinking, 22, 267, 304, 305, 311, 322

T

Taylor, Frederick, 276
team performance, 122
technological forecasting models, 47–48
technology assessment, 28, 54
  interpreting results, 52
  operational evaluation, 52
  recommendations and results, 54
  scenario evaluation, 52
  technology audit, 50
  technology evaluation, 52
technology Assessment, 390
terms and conditions, 108, 198, 199, 364, 366
The Fifth Discipline, 122, 304, 306, 318
total quality management (TQM), 15, 20, 36, 106, 137, 140, 155, 157, 177–81, 207, 385
  FMEA, 136
trade associations, 71, 232, 266, 368
trend analysis, 28, 46–49, 390
  judgmental models, 46–47
  manufacturing processes, 46–49
  process, 49

U

Uniform Contract Format (UCF), 15, 20, 191, 192, 195, 225, 385, 390

W

win-win, 61, 111, 341, 342, 343, 366
workforce diversity, 269
Workforce Diversity, 390
working capital management, 159

Z

zero-based budgeting, 207