

Techniques in Reverse Engineering and New Product Development



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Product Design

**Techniques in Reverse Engineering
and New Product Development**

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Massachusetts

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Dedicated to Ginger—my wonderful wife, partner, companion and friend, whom I dearly love.

Kevin

To those that bring light to my life and spirit: above all, the Lord Jesus Christ; my loving wife Laurie; my precious children Katie, Emily, and Zachariah; their grandparents, Sharon, Del, Bob, and Judith; and in special memory of my grandparents, Bert and Lee Armstrong, who first kindled my inquisitive nature.

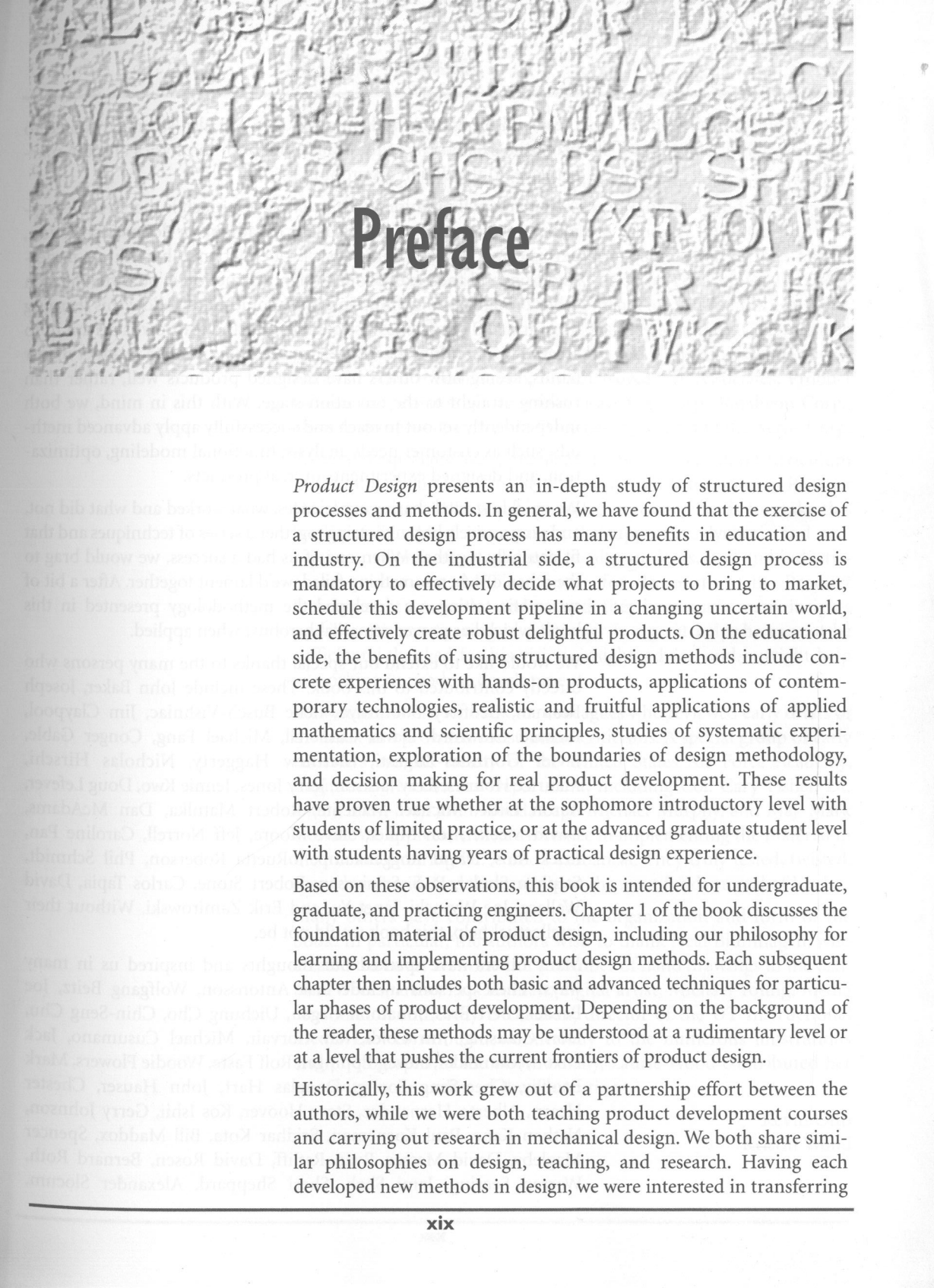
Kristin

Foreword

Many American companies have come to realize that the ability to consistently define and deliver products to the marketplace more rapidly and efficiently than their competitors can become a source of sustainable competitive advantage. These companies have moved to view their product development capability as an end-to-end business process that can be greatly enhanced through re-engineering and can be continuously improved through total quality management. In this environment, the practice of engineering is critical to the success of the process and is as important as the implementation of the engineering sciences. K. N. Otto and K. L. Wood have presented an approach to product design based on "state of the art" engineering methods, tools, and processes that when utilized within the discipline of an overall product development process, depicts a very powerful practice of design. Both students and practitioners will find this approach not only effective and practical, but also immediately applicable to today's design challenges.

Maurice F. Holmes

Vice President, Chief Engineer of Product Design
Xerox Corporation



Preface

Product Design presents an in-depth study of structured design processes and methods. In general, we have found that the exercise of a structured design process has many benefits in education and industry. On the industrial side, a structured design process is mandatory to effectively decide what projects to bring to market, schedule this development pipeline in a changing uncertain world, and effectively create robust delightful products. On the educational side, the benefits of using structured design methods include concrete experiences with hands-on products, applications of contemporary technologies, realistic and fruitful applications of applied mathematics and scientific principles, studies of systematic experimentation, exploration of the boundaries of design methodology, and decision making for real product development. These results have proven true whether at the sophomore introductory level with students of limited practice, or at the advanced graduate student level with students having years of practical design experience.

Based on these observations, this book is intended for undergraduate, graduate, and practicing engineers. Chapter 1 of the book discusses the foundation material of product design, including our philosophy for learning and implementing product design methods. Each subsequent chapter then includes both basic and advanced techniques for particular phases of product development. Depending on the background of the reader, these methods may be understood at a rudimentary level or at a level that pushes the current frontiers of product design.

Historically, this work grew out of a partnership effort between the authors, while we were both teaching product development courses and carrying out research in mechanical design. We both share similar philosophies on design, teaching, and research. Having each developed new methods in design, we were interested in transferring

these and others' methods into practice. We also strongly wanted to bring the excitement of the real world, both in physics and the marketplace, to the design classroom.

A fundamental premise of our teaching approach is that reverse engineering and teardowns offer a better paradigm for design instruction, permitting a modern learning cycle of experience, hypothesis, understanding, and then execution. Design instruction is no different than other domains; to learn design one should both follow this learning cycle and DO design. Reverse engineering and teardowns permit us to achieve this combined goal. We begin with a concrete product in our hands, seeing how others have designed products well, rather than rushing straight to the execution stage. With this in mind, we both independently set out to teach and successfully apply advanced methods, such as customer needs analysis, functional modeling, optimization, and designed experiments on real products.

We quickly started sharing experiences, what worked and what did not, and progressively began to string together a series of techniques and that fit naturally together. When one of us had a success, we would brag to the other, or when something failed, we'd lament together. After a bit of systematic testing, we developed the methodology presented in this book, which has proved remarkably robust when applied.

We would like to extend our special thanks to the many persons who directly contributed to this book. These include John Baker, Joseph Beaman, Geoffrey Boothroyd, Ilene Busch-Vishniac, Jim Claypool, Richard Crawford, David Cutherell, Michael Fang, Conger Gable, Javier Gonzales-Zugasti, Matthew Haggerty, Nicholas Hirschi, Maurice Holmes, Jerry Jackson, Jerry Jones, Jennie Kwo, Doug Lefever, Aaron Little, Michael Manente, Robert Matulka, Dan McAdams, David Meeker, Jon Miller, Steve Moore, Jeff Norrell, Caroline Pan, Erick Rios, David Roggenkamp, JoRuetta Roberson, Phil Schmidt, Stephen Shuler, R. S. Srinivasan, Robert Stone, Carlos Tapia, David Wallace, Joe Wysocki, Janet Yu, and Erik Zamirowski. Without their intellectual help, this book would not be.

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PREFACE

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Many others have contributed to the organization and form of the book. In particular, the authors wish to thank Neal Blumhagen, who created the cover artwork and a number of hand drawings in the text. Ann Weeks, artist, Erik Zumalt, digital artist, Michael Young, media coordinator, and Sicily Dickenson, director of the UT Instructional Media Lab, contributed wonderfully to the numerous illustrations and photographs in the book. Finally, Laurie Wood contributed her creativity to a number of the illustrations.

Kevin Otto
Kristin Wood

Table of Contents

Foreword.....	xxi
Preface.....	xxiii

Chapter 1: Journeys in Product Development **1**

1.1 Chapter Roadmap	3
1.2 An Introduction to Product Design	3
Thoughts for the Reader and Student of Product Design	3
Product Development versus Design	5
Types of Design and Redesign	7
What is Engineering Design?	9
1.3 Modern Product Development	12
A Modern Product Development Process	13
A Reverse Engineering and Redesign Product Development Process	21
1.4 Examples of Product Development Processes	27
Systems: Xerox Corporation	27
Industrial Design: Design EDGE, Austin TX Product Design Firm	30
Rapid: Microsoft Corporation	32
Research Intensive: Raychem Corporation	35
Complex: Ford Motor Company	38
Technical: Raytheon Corporation	40
1.5 Theories and Methodologies in Design	41
1.6 Summary and “Golden Nuggets”	48
References	48

Chapter 2: Product Development Process Tools **51**

2.1 Chapter Roadmap	53
2.2 Product Development Teams	54
The Basics of Teams	55

TABLE OF CONTENTS

Team Composition: Seeking Synergy, Unity, Competence, and Consensus	56
Strategies: Team Structures	62
Team Building (Basic Activities)	65
Team Evaluation	71
Closing: Product Development Teams	74
2.3 Product Development Planning	74
Planning Process	75
Basic Planning and Scheduling Tools	77
2.4 Summary and “Golden Nuggets”	79
References	81

Chapter 3: Scoping Product Developments: Technical and Business Concerns

83

3.1 Chapter Roadmap	85
3.2 Determining What to Develop	86
S-Curves	86
S-Curves and New Product Development	88
Comments on S-curves and Technology Forecasting	91
3.3 Basic Method: Mission Statement and Technical Questioning	93
Technical Questioning	93
Mission Statements	94
Finger Nail Clipper: Clarification and Mission Statement	95
3.4 Advanced Method: Business Case Analysis	97
Harvard Business Case Methodology: Product Evolution	98
Product Development Economic Analysis	99
3.5 Advanced Method: Design Drivers	104
Design Drivers	104
Example: Finger Nail Clipper	108
3.6 Summary and “Golden Nuggets”	110
References	110

Chapter 4: Understanding Customer Needs

111

4.1 Chapter Roadmap	112
4.2 Customer Satisfaction	112
Voice of the Customer	112
Customer Populations	115
Types of Customer Needs	116
Customer Need Models	117
4.3 Gathering Customer Needs	118
Need Gathering Methods	118

TABLE OF CONTENTS

Conducting Interviews: Like/Dislike Method	120
Conducting Interviews: Articulated-Use Method	123
Customer Interviews: Product Feel and Industrial Design	129
4.4 Organizing and Prioritizing Customer Needs	130
Grouping Interpreted Needs	130
Grouping the Needs--Affinity Diagram Method	130
Determining Need Importance	133
Customer Use Patterns	141
Customer Needs Documentation	144
4.5 Summary and "Golden Nuggets"	145
References	145

Chapter 5: Establishing Product Function 147

5.1 Chapter Roadmap	148
5.2 Why Functional Decomposition?	148
Motivation	148
Function Modeling Basics	151
Functions and Constraints	152
5.3 Modeling Process	153
5.4 A Simple Approach: Function Trees	154
The FAST Method	154
The Subtract and Operate Procedure	159
5.5 Establishing System Functionality: Creating a Function Structure	162
The Basics of Function Structures: Black Box and Definitions	162
The Function Structure Modeling Process	167
Phase 1 — Develop Process Descriptions as Activity Diagrams	167
Phase 2 — Formulate Subfunctions Through Task Listing	168
Phase 3 — Aggregate Subfunctions into a Refined Function Structure	174
Phase 4 — Validate the Functional Decomposition	174
Phase 5 — Establish and Identify Product Architecture and Assemblies	176
5.6 Augmentation: From Simple Function Trees to Complete Models	177
An Example of Hierarchical Function Structure Decomposition	179
Bringing Flows into the Functional Hierarchical Decomposition	180
5.7 Aggregation Revisited: Simplicity of Shooting Darts	181
5.8 A Functional Common Basis	187
The Common Basis	188
Transforming Functional Models	189
Uses of a Common Basis	190
Aggregate Function Study	191
5.9 Critique of Functional Modeling Methods	192
5.10 Summary and "Golden Nuggets"	194
References	194

Chapter 6: Product Teardown and Experimentation 197

6.1 Chapter Roadmap	198
6.2 Teardown Process	200
Overview	200
STEP 1. List the Design Issues	201
STEP 2. Prepare for Product Tear Downs	202
STEP 3. Examine the Distribution and Installation	202
STEP 4. Disassemble, Measure, and Analyze Data by Assemblies	203
STEP 5. Form a Bill of Materials	203
6.3 Teardown Methods	204
Subtract and Operate Procedure	204
SOP Examples	206
Force Flow (Energy Flow Field) Diagrams	212
Measurement and Experimentation	220
6.4 Post Teardown Reporting	234
Disassembly Plan and BOM	234
Exploded Views with Highlighted Features	236
Actual Product Function Structure (Network)	236
6.5 Applications of Product Teardown	238
Application: Slide-Out Auxiliary Visor	239
Case Study of an Automatic Iced Tea Maker	249
6.6 Summary and "Golden Nuggets"	256
References	256

Chapter 7: Benchmarking and Establishing Engineering Specifications 259

7.1 Chapter Roadmap	260
7.2 Background: Know Your Enemy to Know Yourself	260
7.3 A Benchmarking Approach	262
STEP 1: Form a List of Design Issues	262
STEP 2. Form a List of Competitive or Related Products	263
STEP 3: Conduct an Information Search	263
STEP 4: Teardown Multiple Products in Class	268
STEP 5: Benchmark by Function	268
STEP 6: Establish Best in Class Competitors by Function	268
STEP 7: Plot Industry Trends	269
Benchmarking Example: Coffee Mills	270

7.4 Support Tools for the Benchmarking Process	274
Indented Assembly Cost Analysis	274
Function—Form Diagrams	275
Trend Analysis	278
Proposal on Opportunities for Re-design	279
Thoughts on Benchmarking the Competition	280
7.5 Setting Product Specifications	283
Specification Process	284
Basic Method: The House of Quality	289
Advanced Method: Value Analysis	297
7.6 Summary and “Golden Nuggets”	302
References	302

Chapter 8: Product Portfolios and Portfolio Architecture

303

8.1 Chapter Roadmap	304
8.2 Product Portfolio Architecture	304
Background	304
Portfolio Architecture Types	306
8.3 Choosing an Architecture Type	315
Theory	316
Market Basis for Architecture Decisions	318
8.4 Platform Architecture	331
Negotiating a Modular Family Platform	332
Basic Method: Charts	334
Advanced Method: Functional Architecting	339
Advanced Method: Optimization Selection	345
8.5 Summary and “Golden Nuggets”	354
References	355

Chapter 9: Architecture

357

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9.1 Chapter Roadmap	358
9.2 Product Architectures	359
Introduction	359
Architecture Types	360
Architecture Examples	361
9.3 Product Modularity: Background	362

TABLE OF CONTENTS

Types of Modularity	363
9.4 Modular Design: Basic Clustering Method	370
Step 1: Create a Function Structure of the Product	370
Step 2: Cluster the Elements into Module Chunks	371
Step 3: Create a Rough Geometric Layout(s)	374
Step 4: Define Interactions and Detail Performance Characteristics	376
9.5 Modular Design: An Advanced Functional Method	378
Function Dependencies	378
Module Heuristics	379
Process: Application of the Module Heuristics	391
Summary	398
9.6 Architecture-Based Development Teams	399
A Method of Forming Module Based Development Teams	400
Application of Module-Based Development Teams	401
Summary of the Development Team Method	408
9.7 Summary and “Golden Nuggets”	408
References	409

Chapter 10: Generating Concepts

411

10.1 Chapter Roadmap	413
10.2 Concept Generation Process	414
10.3 Basic Methods: Information Gathering and Brainstorming	416
Information Gathering: Conventional Aids	417
Traditional Brainstorming	419
Brain-Ball	424
C-Sketch/6-3-5 Method	425
Idea Generators for Intuitive Techniques	432
10.4 Advanced Methods: Directed Search	433
Systematic Search with Physical Principles	433
Systematic Search with Classifying Schemes	435
Theory of Inventive Problem Solving	443
10.5 Morphological Analysis	454
Develop Concepts for Each Product Function	455
10.6 Combining Solution Principles (Concept Variants)	456
Digression/Caution: Function Sharing	459
Product Application: Fingernail Clipper	460
Product Application: Bilge Water Removal Product	461
Product Application: Smart Spoon to Assist Persons with Disabilities	464
10.7 Summary and “Golden Nuggets”	475
References	476

Chapter 11: Concept Selection 477

11.1 Chapter Roadmap	478
11.2 Introduction	478
Factors that Determine Effective Decision Making	479
Design Evaluations	480
Information Quality	480
11.3 Estimating Technical Feasibility	482
Estimation	483
Example: Air Conditioning for an Electric Vehicle	484
Estimating Hints	486
11.4 A Concept Selection Process	487
Forming Consensus on the Criteria	489
Forming Consensus on the Alternatives	491
Ranking	492
Assessment	492
Attacking the Negatives	493
11.5 A Basic Method: Pugh Concept Selection Charts	493
Establish the Criteria and Alternatives	494
Select a Datum	494
Ranking and Assessment	495
Alternative Rank Ordering	496
Attacking the Negatives	496
Iteration and Solution	497
Example: Coffee Mill	497
11.6 Advanced Discussion: Measurement Theory	500
Set Structure of Evaluation	500
Ordinal Scales	501
Interval Scales	506
Ratio Scales	511
Extensively Measurable Scales	513
11.7 Advanced Method: Numerical Concept Scoring	513
Scoring with Interval Scales	513
Selection Error Analysis	517
Concept Selection with Error Analysis:	
Design of a Cat Litter Box Product	527
11.8 A Critique of Design Evaluation Schemes	532
11.9 Chapter Summary and "Golden Nuggets"	533
References	533

Chapter 12: Concept Embodiment 535

12.1 Chapter Roadmap	536
12.2 Overview and Context	537
12.3 Basic Methods: Refining Geometry and Layout	542
General Process of Product Embodiment	543
Embodiment Checklist	546
12.4 Advanced Methods: Systems Modeling	550
Systems Modeling	550
Mechanical Embodiment Principles	555
FMEA Method: Linking Fault States to Systems Modeling	565
12.5 Case Study: Computer Monitor Stand for a Docking Station	571
Summary	595
12.6 Summary and "Golden Nuggets"	596
References	600

Chapter 13: Modeling of Product Metrics 603

13.1 Chapter Roadmap	604
13.2 Introduction: Model Selection by Performance Specifications	604
Model Preparation and Selection Method	606
Product Application: Model Preparation and Selection	607
13.3 Mathematical Modeling versus Physical Prototyping	610
Example	610
13.4 Advanced Topic: What is a Product Model?	614
Informal Models	614
Formal Models	615
13.5 Constructing Product Models: basic Method	622
A Basic Modeling Approach	623
A Product Application in Constructing Basic Models: Iced Tea Maker	632
13.6 Constructing Product Models: Advanced Method	644
Approach	645
Method	645
13.7. Product Models: Cases	648
Electric Wok Product	648
Handle Temperature	654
Other Metrics to Integrate a Complete Model	658
Comments on Design Model Validation	660
13.8 Summary and "Golden Nuggets"	661
References	662

Chapter 14: Design for Manufacture and Assembly 663

14.1 Chapter Roadmap	664
14.2 Overview and Motivation	665
14.3 Basic Method: Design Guidelines	666
Design for Assembly	667
Design for Piece Part Production	675
14.4 Advanced Method: Manufacturing Cost Analysis	685
Cost Driver Modeling	686
Manufacturing Cost Analysis	690
14.5 Critique of Design for Assembly Methods	709
14.6 Chapter Summary and Golden Nuggets	716
References	716

Chapter 15: Design for the Environment 719

15.1 Chapter Roadmap	721
15.2 Why DFE?	722
15.3 Environmental Objectives	722
Global Issues	723
Regional and Local Issues	724
15.4 Basic DFE Methods: Design Guidelines	725
Application: Paper Carrier Design	725
15.5 Life Cycle Assessment	733
Overview	733
Basic Method: AT&T's Environmentally Responsible Product Assessment	738
Weighted Sum Assessment Method	744
Life Cycle Assessment Method	752
15.6 Techniques to Reduce Environmental Impact	753
Design to Minimize Material Usage	754
Design for Disassembly	756
Design for Recyclability	764
Design for Remanufacturing	767
Design for High-Impact Material Reduction	769
Design for Energy Efficiency	771
Design to Regulations and Standards	771
15.7 Chapter Summary and "Golden Nuggets"	777
References	778