

The Logical Thinking Process

A Systems Approach to
Complex Problem Solving

H. William Dettmer

A new edition of Goldratts Theory of Constraints

Table of Contents

<i>Preface</i>	xxiii
<i>Acknowledgments</i>	xxv
<i>Introduction</i>	xxvii
PART I – THE DESTINATION	1
Chapter 1 Introduction to the Theory of Constraints	3
Systems and “Profound Knowledge”	4
The System’s Goal	5
The Manager’s Role	5
<i>Who Is a Manager?</i>	5
<i>What Is the Goal?</i>	6
<i>Goal, Critical Success Factor, or Necessary Condition?</i>	6
The Concept of System Constraints	8
<i>Systems as Chains</i>	8
<i>The “Weakest Link”</i>	8
<i>Constraints and Non-constraints</i>	9
<i>A Production Example</i>	9
Relation of Constraints to Quality Improvement	10
Change and the Theory of Constraints	11
TOC Principles	12
<i>Systems as Chains</i>	12
<i>Local vs. System Optima</i>	12
<i>Cause and Effect</i>	13
<i>Undesirable Effects and Critical Root Causes</i>	13
<i>Solution Deterioration</i>	14
<i>Physical vs. Policy Constraints</i>	14
<i>Ideas Are NOT Solutions</i>	14
The Five Focusing Steps of TOC	14
1. <i>Identify the System Constraint</i>	14
2. <i>Decide How to Exploit the Constraint</i>	14
3. <i>Subordinate Everything Else</i>	15
4. <i>Elevate the Constraint</i>	15
5. <i>Go Back to Step 1, but Beware of “Inertia”</i>	15

Throughput, Inventory, and Operating Expense	16
<i>Throughput (T)</i>	16
<i>Inventory/Investment (I)</i>	17
<i>Operating Expense (OE)</i>	17
<i>Which Is Most Important: T, I, or OE?</i>	17
<i>T, I, and OE: An Example</i>	18
<i>T, I, and OE in Not-for-Profit Organizations</i>	19
<i>Universal Measures of Value</i>	19
<i>Passive Inventory</i>	20
<i>Active Inventory (Investment)</i>	20
<i>Managing T Through Undesirable Effects</i>	20
The TOC Paradigm	21
<i>Applications and Tools</i>	21
<i>Drum-Buffer-Rope</i>	21
<i>Critical Chain Project Management</i>	21
<i>Replenishment and Distribution</i>	22
<i>Throughput Accounting</i>	22
<i>The Logical Thinking Process</i>	22
The Goal Tree	22
The Current Reality Tree	23
The Evaporating Cloud: A Conflict Resolution Diagram	24
The Future Reality Tree	25
The Prerequisite Tree	25
The Transition Tree	27
The Categories of Legitimate Reservation	28
The Logical Tools as a Complete "Thinking Process"	29
Figure 1.19: The Six Logical Tools as an Integrated Thinking Process	30
Chapter 2 Categories of Legitimate Reservation	31
Definition	32
Purpose	32
Assumptions	33
How to Use This Chapter	34
Description of the Categories of Legitimate Reservation	34
1. <i>Clarity</i>	34
<i>Why Clarity Comes First</i>	34
<i>What Clarity Means</i>	34
2. <i>Entity Existence</i>	36
<i>Completeness</i>	36
<i>Structure</i>	36
<i>Validity</i>	38
3. <i>Causality Existence</i>	38
4. <i>Cause Insufficiency</i>	40
<i>The Ellipse</i>	40
<i>Relative Magnitude of Dependent Causes</i>	42
<i>How Many Arrows?</i>	42
<i>The Concept of "Oxygen"</i>	42
5. <i>Additional Cause</i>	44
<i>Magnitude</i>	44
<i>Test</i>	44
<i>A Unique Variation of Additional Cause</i>	44

Complex Causality	46
<i>What Is It?</i>	46
<i>Cause Sufficiency</i>	46
Conceptual "AND"	46
Additional Cause	46
Magnitudinal "AND"	47
Exclusive "OR"	47
Symbols	48
6. <i>Cause-Effect Reversal</i>	49
The "Fishing Is Good" Example	49
The Statistical Example	49
The Medical Example	49
Test	50
7. <i>Predicted Effect Existence</i>	50
Conflict or Differences in Magnitude?	51
Tangible or Intangible?	52
Verbalizing Predicted Effect Existence	54
8. <i>Tautology (Circular Logic)</i>	55
Baseball Example	56
Vampire Example	56
Test	56
Using the CLR in a Group	57
<i>CLR Known by All</i>	58
<i>CLR Known Only by the Tree-Builder</i>	58
Sufficiency-Based vs. Necessity-Based Logic Trees	59
Symbols and Logic Tree Conventions	59
<i>Three Reasons to Standardize</i>	59
Credibility	60
Ergonomics	60
Miscommunication of Logic	60
<i>A Standard Symbol Set</i>	61
<i>A Standard Convention for Logical Connections</i>	62
Summary	64
Figure 2.36: Categories of Legitimate Reservation: Self-Scrutiny Checklist	65
Chapter 3 Goal Tree	67
Introduction	68
Definition	68
Purpose	68
Assumptions	68
How to Use This Chapter	69
System Boundaries, Span of Control, and Sphere of Influence	69
<i>Span of Control</i>	70
<i>Sphere of Influence</i>	70
<i>The External Environment</i>	70
<i>Control vs. Influence</i>	70
Doing the Right Things vs. Doing Things Right	70
<i>The Goal</i>	70
<i>Who Sets the Goal?</i>	71
<i>Critical Success Factors and Necessary Conditions</i>	72

Description of the Goal Tree	72	Arrows	110
Strategic Application	73	Underlying Assumptions	111
A Hierarchy of Systems	73	Ellipses, Magnitudinal ANDs, and Exclusive ORs	112
GTs Are Unique	74	Ellipses	112
Characteristics of the GT	75	Magnitudinal ANDs	113
Examples of Strategic Goal Trees	76	Exclusive ORs	114
Process-Level GT	76	Variations on a Theme	115
System-Level GT	76	Numbering Entities in a Tree	115
How to Construct a Goal Tree	76	The Most Common Logical Errors in a Sufficiency Tree	118
1. Define the System	76	Clarity in the Arrow	118
2. Determine the System Goal	78	Don't Induce Confusion	119
3. Determine the Critical Success Factors	79	Don't Miss Opportunities to Break the Chain of Cause and Effect	119
4. Determine the Key Necessary Conditions	80	Cause Insufficiency	120
5. Arrange the GT Components	82	The Concept of "Oxygen" Revisited	121
6. Connect the Goal, Critical Success Factors, and Necessary Conditions	82	Entity Existence	122
7. Verify the Connections	83	Reading a Current Reality Tree	122
The "10,000-Foot Test"	85	Negative Reinforcing Loops	124
8. Enlist Outside Scrutiny of the Entire GT	85	Reading a Negative Reinforcing Loop	125
Figure 3.14: Procedures for Constructing a Goal Tree – abbreviated checklist	86	How to Construct a Current Reality Tree	126
Summary and Conclusion	87	Gather Materials	127
Figure 3.15: Example: A Real-World GT	88	1. Define the System to be Modeled	128
PART II – GAP ANALYSIS AND CORRECTION	89	2. Determine the Undesirable Effects	128
Chapter 4 Current Reality Tree	91	Compare Reality with Benchmarks of System Success	129
Definition	92	Create a Starting Matrix	129
Purpose	93	3. Determine the First Two Levels of Causality	130
Assumptions	94	Transfer UDEs and Causes to Post-it Notes	130
How to Use This Chapter	94	4. Begin the Current Reality Tree	131
Description of the Current Reality Tree (CRT)	95	5. Improve the Logic of the Initial Clusters	131
A Single Tool or Part of a Set	96	6. Identify Possible Additional Causes	133
Span of Control and Sphere of Influence	97	Two Criteria for Additional Causes	134
Correlation vs. Cause and Effect	98	7. Look for Lateral Connections	135
Predicting Rain in Siberia: A Simple Example of Correlation	98	8. Build the Cause-and-Effect Chains Downward	136
Fibromyalgia and Myofascial Pain: A Complex Real-World Example	99	9. Scrutinize the Entire Current Reality Tree	137
Undesirable Effects	100	10. Decide Which Root Causes to Attack	138
Undesirable by What Standard?	100	Scrutinizing the Current Reality Tree	140
How to Identify and Check for Undesirability	101	The Categories of Legitimate Reservation	140
Existence in Reality	101	Techniques for "Shortstopping" Logical Challenges	140
Why the Emphasis on UDEs?	102	When "All" or "None" Are Not Acceptable	141
Root Causes	102	Inclusive and Exclusive	141
Core Problems and Root Causes	105	Qualifying Words	141
The "70 Percent" Criterion	105	Too Many Arrows?	142
Inability to Act on a Core Problem	105	Simple Logical Aid #1: Means, Method, and Motivation	143
A Solution to the Core Problem Conundrum	106	Simple Logical Aid #2: The Syllogism	144
Critical Root Cause: A Definition	108	Using the CRT with Other Parts of the Thinking Process	146
Main Body of the CRT	108	The Current Reality Tree and the Evaporating Cloud	146
Archetypical CRTs	109	The Current Reality Tree and the Future Reality Tree	146
Depicting a Current Reality Tree	109	Summary	147
Entities	109	Figure 4.45: Procedures for Constructing a Current Reality Tree (CRT) – abbreviated checklist	148
Entities in a Current Reality Tree	110	Figure 4.46: Current Reality Tree: Fordyce Corporation	152

Chapter 5 Evaporating Cloud	159
Definition	160
Purpose	161
Assumptions	161
How to Use This Chapter	162
Description of the Evaporating Cloud	162
<i>The Nature of Conflict</i>	163
<i>Conflict Is Not Always Obvious</i>	163
<i>Two Types of Conflict</i>	163
Opposite Conditions	163
Different Alternatives	163
<i>Compromise, "Win-Lose" or "Win-Win"?</i>	163
Compromise	164
Win-Lose	164
Win-Win	164
<i>An Indication of Hidden Conflict</i>	164
<i>"Breakthrough Solutions"</i>	164
<i>Elements of the Evaporating Cloud</i>	165
<i>Symbology</i>	165
Objective	166
Requirements	166
Prerequisites	168
<i>How the Evaporating Cloud Relates to the Current Reality Tree</i>	169
Why Do Root Causes of Undesirable Effects Exist?	171
Policies and Constraints	171
Policy Constraints: A Source of Conflict	171
Conflict is Usually Embedded in the CRT	172
<i>Assumptions</i>	172
Invalid Assumptions	172
Some Assumptions Can Be Invalidated	173
"Win-Win" vs. "Win-Lose"	175
Five Potential "Break" Points	175
Invalid Assumptions: An Example	176
<i>Injections: The Role of Invalid Assumptions</i>	177
How Are Injections Related to Assumptions?	178
Injections: Actions or Conditions?	180
"Silver Bullets"	180
<i>Creating "Breakthrough" Ideas to Resolve Conflict</i>	180
All Arrows Are Fair Game	181
Is the Idea Feasible?	182
<i>Reading an Evaporating Cloud</i>	182
Verbalizing Assumptions	182
What to Remember About Evaporating Clouds	183
How to Construct An Evaporating Cloud	184
<i>A Nine-Step Path to Conflict Resolution</i>	184
1. Construct a Blank Evaporating Cloud	185
2. Articulate the Conflicting "Wants" of Each Side	185
3. Determine the "Needs" of Each Side	186
The "Easy Way" to Articulate Requirements	187
4. Formulate the Objective	188
Why Use a Goal Tree?	188

5. Evaluate the Whole Relationship	190
6. Develop Underlying Assumptions	192
Extreme Wording	192
7. Evaluate Assumptions	194
8. Create Injections	195
9. Select the Best Injection(s)	195
Scrutinizing An Evaporating Cloud	197
Reflection of Current Reality	197
Perception	198
Figure 5.32: Procedures for Constructing an Evaporating Cloud – abbreviated checklist	199
Figure 5.33: Evaporating Cloud: Master Blank Form	202
Figure 5.34: Evaporating Cloud: Wurtzburg Corporation	203
Summary	204
Chapter 6 Future Reality Tree	205
Definition	206
Purpose	207
Assumptions	208
How to Use This Chapter	208
Description of the Future Reality Tree	209
<i>A Real-World Example</i>	209
<i>A Framework for Change</i>	210
<i>Negative Branches</i>	211
<i>The Positive Reinforcing Loop</i>	211
<i>Future Reality Tree Symbology</i>	213
<i>Injections</i>	214
Injections: Actions or Conditions?	215
The Risk of Actions as Injections	216
<i>Build Upward, from Injections to Desired Effects</i>	216
Example: Building a House	217
<i>Multiple Injections: The "Silver Bullet" Fallacy</i>	217
<i>Where Injections Come From</i>	217
<i>The Future Reality Tree and Other Thinking Process Trees</i>	219
The Future Reality Tree and the Current Reality Tree	219
The Logical Structure of Reality, Current and Future	220
The Future Reality Tree and the Evaporating Cloud	221
The Future Reality Tree and the Prerequisite Tree	222
The Future Reality Tree as a "Safety Net"	225
<i>Negative Branches</i>	225
Using the Negative Branch as a "Stand-Alone"	225
Added Realities	226
Assumptions	228
"Trimming" Negative Branches	228
When to Raise Negative Branch Reservations	228
<i>Positive Reinforcing Loops</i>	228
<i>Strategic Planning with a Future Reality Tree</i>	230
How to Construct a Future Reality Tree	231
1. Gather Necessary Information and Materials	231
2. Formulate Desired Effects	232
Positive, Not Neutral	232

Use Present Tense	233
Lay Out Desired Effects	233
3. Add the Injection(s) and Evaporating Cloud Requirements	234
Where Do We Find Injections?	234
Injections at the Bottom	235
4. Fill in the Gaps	235
Build Upward	235
Continue Building from the Expected Effects	235
5. Build in Positive Reinforcing Loops	237
6. Look for Negative Branches	238
7. Develop Negative Branches	240
8. Trim Negative Branches	240
9. Incorporate the "Branch-Trimming" Injection into the FRT	241
10. Scrutinize the Entire FRT	241
Scrutinizing a Future Reality Tree	242
Existence Reservations	242
Additional Cause	242
Scrutinizing Injections	243
"Oxygen"	243
Summary	243
Figure 6.27: Procedures for Constructing a Future Reality Tree	244
Figure 6.28: Using the Negative Branch as a Stand-Alone Tool	248
Figure 6.29: Future Reality Tree Example: Fordyce Corporation	252
PART III – EXECUTING CHANGE	259
Chapter 7 Prerequisite and Transition Trees	261
A Consolidation of Two Trees	262
Definition	263
Purpose	264
Assumptions	264
How to Use This Chapter	265
Description of the Prerequisite Tree	265
Necessity vs. Sufficiency	265
Depicting a Prerequisite Tree	267
The Objective	267
Intermediate Objectives	268
Different Alternatives	270
Not Always a One-to-One Relationship	270
Obstacles	270
Overcome, Not Obliterate	271
Enlist Assistance to Identify Obstacles	272
A Single Tool or Part of a Set	272
Intermediate Objectives: Actions or Conditions?	272
Obstacles: Always Conditions	273
Sequence Dependency	274
Parallelism	274
Reading a Prerequisite Tree	276
Top to Bottom	277
Bottom to Top	278

Building a Prerequisite Tree	279
1. Determine the Objective	279
2. Identify All Intermediate Objectives	279
3. Surface All Possible Obstacles	281
4. Organize the Intermediate Objectives and Obstacles	281
5. Sequence the Intermediate Objectives Within Each Branch	284
6. Connect the Intermediate Objectives	285
7. Overcome the Obstacles	285
8. Integrate the Branches	287
9. Connect the Main Body of the Tree to the Objective	289
10. Scrutinize the Entire Tree	290
Scrutinizing a Prerequisite Tree	290
Entity Existence	291
Cause Sufficiency	291
Additional Cause	292
The IO-Obstacle Validity Test	292
The Transition Tree	294
A Little History	294
Prerequisite Tree and Transition Tree: Original Concept	295
Transition Tree Structure	297
The Five-Element Transition Tree	299
In Search of Robust Execution	300
Managing Change as a Project	300
Critical Chain Project Management	300
What Critical Chain Project Management Does	300
What Critical Chain Project Management Requires	301
A Three-Phase Change Management Framework	301
Summary	302
Figure 7.31: Procedures for Constructing a Prerequisite Tree	304
Figure 7.32: Prerequisite Tree Self-Scrutiny Checklist	307
Figure 7.33: Prerequisite Tree: Conference Planning and Management	308
Chapter 8 Changing the Status Quo	311
Purpose	312
Assumptions	312
How to Use This Chapter	313
The Key to System Improvement	313
The Elements of System Improvement	314
Reinforcement	315
Human Behavior	315
Active Resistance	315
Passive Resistance	316
Is Behavior Logical?	316
Changing Minds, or Changing Behavior?	316
Why Do People Resist Change?	317
Maslow	317
Herzberg	318
McClelland	318
Adams	318
Anaclitic Depression Blues	319
Security or Satisfaction?	320

<i>The Impact on Solutions</i>	320
Leadership	322
<i>Leadership Is About People</i>	322
<i>Leadership and the Blitzkrieg</i>	323
Mutual Trust	323
Personal Professional Skill	323
Moral Contract	324
Focus	324
Level 5 Leadership	325
Leadership and Behavior	325
<i>The Leader's Behavior</i>	327
<i>Subordinates' Behavior</i>	328
Creating and Sustaining Desired Behaviors	328
<i>Behavior Change is a Leadership Function</i>	329
<i>A Behavioral Approach to Change</i>	329
Rewards or Reinforcement?	330
A General Strategy for Implementing Change	331
<i>A Common Scenario</i>	331
Assumptions	331
How Change "Gets In"	323
<i>The Leader as Change Agent-in-Chief</i>	323
<i>A Model for Implementing Change</i>	333
1. Leader Commitment	335
2. Modified Behavior Defined	335
3. Mission/Task Charter Communicated	335
4. Leader Commitment Demonstrated	336
5. Subordinate Commitment	336
6. Performance Management Process	336
<i>A Last Thought about Ensuring Effective Change</i>	336
Summary	337
Epilogue	339
Appendices	
Appendix A: Strategic Goal Tree	341
Appendix B: Executive Summary Trees	343
Appendix C: Current Reality Tree Exercise	356
Appendix D: Evaporating Cloud Exercise	357
Appendix E: The 3-UDE Cloud	359
Appendix F: The Challenger Conflict	369
Appendix G: Correlation Versus Cause and Effect	376
Appendix H: Theories of Motivation	377
Appendix I: Legal Application of the Thinking Process	382
Appendix J: Transformation Logic Tree Software	394
<i>Glossary of Thinking Process Terms</i>	397
<i>Bibliography</i>	401
<i>Index</i>	405

List of Illustrations

Figure 1.1	A basic system and its environment	4
Figure 1.2	Goal or critical success factor?	7
Figure 1.3	A system: the "chain" concept	8
Figure 1.4	A production example	9
Figure 1.5	Another version of the production example	10
Figure 1.6	Who is working on a non-constraint?	11
Figure 1.7	Partial list of TOC principles	13
Figure 1.8	Definitions of Throughput, Inventory, and Operating Expense	16
Figure 1.9	Limits to T, I and OE	18
Figure 1.10	Management priorities with T, I, and OE	18
Figure 1.11	T, I, and OE in a not-for-profit organization	20
Figure 1.12	The Goal Tree	23
Figure 1.13	The Current Reality Tree	24
Figure 1.14	The Evaporating Cloud (conflict resolution diagram)	25
Figure 1.15	The Future Reality Tree	26
Figure 1.16	The Prerequisite Tree	27
Figure 1.17	The Transition Tree	28
Figure 1.18	How the logic trees relate to four management questions about change	29
Figure 1.19	The six logical tools as an integrated Thinking Process	30
Figure 2.1	A test and example of the clarity reservation	35
Figure 2.2	Completeness	36
Figure 2.3	Structure: compound entity	36
Figure 2.4	Structure: embedded "if-then"	37
Figure 2.5	Validity	38
Figure 2.6	A test and example of the entity existence reservation	39
Figure 2.7	Causality existence	39
Figure 2.8	Tangible vs. intangible causes	40
Figure 2.9	A test and example of the causality existence reservation	41
Figure 2.10	Indicating cause sufficiency with an ellipse	41
Figure 2.11	How many contributing causes?	42
Figure 2.12	The concept of "oxygen"	43
Figure 2.13	A test and example of the cause insufficiency reservation	44
Figure 2.14	Additional cause	44
Figure 2.15	Variation of additional cause	45
Figure 2.16	A test and example of the additional cause reservation	46
Figure 2.17	Simple causality	46
Figure 2.18	Conceptual "AND"	47
Figure 2.19	Additional cause	47
Figure 2.20	Magnitudinal "AND"	48
Figure 2.21	Exclusive "OR"	49