

Building
LEAN
Supply Chains



with the
THEORY of
CONSTRAINTS

Mandyam M. Srinivasan

Building Lean Supply Chains with the Theory of Constraints

Mandyam M. Srinivasan



New York Chicago San Francisco
Lisbon London Madrid Mexico City
Milan New Delhi San Juan
Seoul Singapore Sydney Toronto

Library of Congress Cataloging-in-Publication Data

Srinivasan, Mandyam M.

Building lean supply chains with the theory of constraints / Mandyam M. Srinivasan.
p. cm.

ISBN 978-0-07-177121-4 (alk. paper)

1. Business logistics. 2. Lean manufacturing. 3. Quality control. 4. Cost control. I. Title.
HD38.5.S6557 2012
658.7—dc23

2011038559

McGraw-Hill books are available at special quantity discounts to use as premiums and sales promotions, or for use in corporate training programs. To contact a representative please e-mail us at bulksales@mcgraw-hill.com.

Building Lean Supply Chains with the Theory of Constraints

Copyright © 2012 by The McGraw-Hill Companies, Inc. All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a data base or retrieval system, without the prior written permission of the publisher.

1 2 3 4 5 6 7 8 9 0 QFR/QFR 1 9 8 7 6 5 4 3 2 1

ISBN 978- 0-07-177121-4

MHID 0-07-177121-2

The pages within this book were printed on acid-free paper.

Sponsoring Editor

Judy Bass

Acquisitions Coordinator

Bridget Thoreson

Editorial Supervisor

David E. Fogarty

Project Manager

Patricia Wallenburg

Copy Editor

Jim Madru

Proofreader

Claire Splan

Indexer

Judy Davis

Production Supervisor

Pamela A. Pelton

Composition

TypeWriting

Art Director, Cover

Jeff Weeks

Information contained in this work has been obtained by The McGraw-Hill Companies, Inc. ("McGraw-Hill") from sources believed to be reliable. However, neither McGraw-Hill nor its authors guarantee the accuracy or completeness of any information published herein, and neither McGraw-Hill nor its authors shall be responsible for any errors, omissions, or damages arising out of use of this information. This work is published with the understanding that McGraw-Hill and its authors are supplying information but are not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought.

Building Lean Supply Chains with the Theory of Constraints

About the Author

Mandyam M. Srinivasan is the Pilot Corporation Chair of Excellence at the University of Tennessee. He is the author of *Streamlined: 14 Principles for Building and Managing the Lean Supply Chain* (Cengage, 2004), and coauthor of *Supply Chain Management for Competitive Advantage* (Tata McGraw-Hill, 2009). Dr. Srinivasan has many years of work experience with leading automobile manufacturing organizations, and he has consulted with a large number of industries.

*To my mother, Mythili;
my wife, Kanchan;
and my daughters, Tanu and Madhu*

FOREWORD

Throughout my 30-year career in the aerospace industry, I have witnessed unparalleled technological advancements in aeronautical systems and capabilities, as well as ground-breaking changes in our business operations. The defense technology and industrial base is now a global network with global suppliers, and our challenge is to manage the resources, skills, competencies, and tools within the network through all phases of the product life cycle.

As enterprises such as ours strive to create and deliver competitive products in this global marketplace, it is more critical than ever to develop and maintain a lean supply chain. But what is the definition of a *lean* supply chain, and how can an organization achieve this ideal? Dr. Srinivasan's book, *Building Lean Supply Chains with the Theory of Constraints*, answers this question and more because he provides an in-depth look at today's lean supply chains and offers a detailed plan on how to realize them.

Outlining a seven-step roadmap that enterprises can use on their lean supply chain journey, Dr. Srinivasan applies Theory of Constraints (TOC) concepts to supply chain management in a thought-provoking and pragmatic way. The book intimately explores building and managing a lean supply chain from an operations and logistics perspective, with Lean and TOC principles combined. Not only does Dr. Srinivasan tackle the importance of systems thinking, but he also applies TOC philosophies to throughput, meeting and anticipating customer needs, delivery requirements, collaboration, and improved visibility of the supply chain, among others.

As Dr. Srinivasan expounds on his seven-step roadmap, he lays the groundwork for what a lean supply chain should look like. Weaving in 16 Lean Supply Chain Principles, the result is a framework that enterprises can use to create and manage their lean supply chains.

In this book, lean supply chains are not assayed from one angle but are considered from multiple vantage points. The initial chapters investigate the hurdles and structure of the lean supply chain, introducing the Theory of

Constraints to enhance Lean supply chain performance. Throughout the book, Dr. Srinivasan leverages real-world scenarios to drive home the necessity of merging Lean and TOC principles.

While this book looks at an integrated approach to supply chain management and sets the expectation that industries partner with the supply chain, Dr. Srinivasan's vision never loses sight of the customer. At Lockheed Martin, our customer is our focus, and we realize that collaborative relationships are the key to our current and future successes, especially when building fifth-generation aircraft such as the F-35 with a supply chain that spans the globe. As we learn more about these relationships in the global market in which we work, we can better understand our customers' needs and plan for tomorrow.

This book is a thoughtful and comprehensive examination of how changing our views on customer needs, supply chain operations, and logistics can produce tangible, meaningful results. It is a guide not only for the supply chain management student or professional but also for anyone interested in learning key supply chain management, operation, and logistics principles.

RALPH D. HEATH
*Executive Vice President of Aeronautics
Lockheed Martin Corporation*

PREFACE

In the early 1990s, I began to teach in executive MBA programs and shorter executive development courses offered through the Center for Executive Education at the University of Tennessee. Having worked in the automobile industry for many years, I was eager to present cutting-edge techniques in my seminars. In particular, I wanted participants to be aware of two powerful techniques that were relatively new at that time: the Theory of Constraints (TOC) and Lean.

At that time, however, most business schools were still teaching traditional disaggregated topics such as location planning, capacity planning, and materials requirement planning. These topics were inadequate to equip professionals to manage enterprises in an increasingly competitive environment. I was unable to find a single book that covered the topics I was interested in teaching. Therefore, in 2004, I published a book entitled, *Streamlined: 14 Principles for Building and Managing the Lean Supply Chain*. *Streamlined* showed how managers could exploit the synergy between TOC and Lean to enhance the flow of products in their supply chain. The concepts and principles from the book were incorporated subsequently in numerous executive MBA programs and executive development courses.

More recently, the general consensus among the participants attending these programs is that the principles of Lean are now fairly well known. Lean applications have extended well beyond the automotive industry to other industries, such as health care and aerospace, to the extent that it almost has become commoditized. TOC, on the other hand, is still a relatively lesser known body of knowledge. The participants attending my programs invariably identify the TOC sessions as adding the most value to their learning experience. In particular, the participants want to know how to apply these TOC concepts to manage the supply chain. Such feedback encouraged me to write this book.

This book, *Building Lean Supply Chains with the Theory of Constraints*, stresses systems thinking. It uniquely integrates TOC with Lean, illustrating

how these two philosophies complement and reinforce each other to create a smooth flow of goods and services through the supply chain.

What Is Unique About This Book?

While *Streamlined* was the first book to explain what a lean supply chain is in depth, it did not fully tap into the vast body of knowledge offered by TOC. TOC is arguably the world's best kept secret for managing businesses from a systems perspective. Until the early 2000s, most of the significant developments in TOC were understood and used by a few select experts in the field. The TOC body of knowledge has since become more widely disseminated in a variety of ways, through conferences, Webinars, and the Internet. This book applies the TOC body of knowledge to building and managing the lean supply chain.

This book still integrates the concepts and principles of TOC and Lean, but the emphasis is on TOC. Most of the chapters draw on the tools and techniques of TOC: Throughput Accounting, Drum-Buffer-Rope, TOC in Distribution and Replenishment, the Thinking Process, and Critical Chain Project Management. All these topics are presented in the context of building and managing the lean supply chain. The concepts presented in this book provide a clear understanding of where to apply Six Sigma and Lean methods to achieve true bottom-line results.

Flow of Material

Supply chains can be addressed from many functional perspectives—financial, marketing, operations, and logistics. This book is concerned with operations and logistics. The flow of material is organized around 16 Lean Supply Chain Principles. The first chapter presents a Lean Supply Chain Roadmap that outlines the seven steps organizations can use to build and manage the lean supply chain. Each one of these steps is presented in seven separate chapters, with each chapter presenting two of the 16 Lean Supply Chain Principles. The final chapter shows how implementation of the lean supply chain or any other project, for that matter, can be executed most effectively using a technique popularly known as *Critical Chain Project Management*, which is the approach prescribed by TOC for project management.

Who Should Read This Book

Although the original intent was to write a book for MBA students, both full time and executive, the book evolved rapidly to one a professional could use readily. It can be a guide for logistics and operations professionals to better manage their activities within the broader context of the supply chain with which they have to deal. At the same time, the book still should be valuable to students in an executive MBA or similar professional program that offers courses in operations, logistics, and supply chain management. It is also a useful reference book for educators, consultants, and practitioners who interact with any element in the supply chain.

MANDYAM M. SRINIVASAN

ACKNOWLEDGMENTS

This book is the product of my interactions with many industry professionals, colleagues, and graduate students over the past decade. These individuals have generously shared their knowledge and enriched my understanding of the supply chain. In particular, one individual, Dr. Eliyahu Goldratt, has profoundly influenced my knowledge and understanding of the concepts covered in this book.

I wish to extend special thanks to Dr. Ken Gilbert and Dr. James Holt for their insights and comments that have helped shaped some of the chapters in this book. Thanks to Dr. Dave Narasimhan for his very generous help with the figures in this book and to Dr. James Reeve for his permission to use the Integrity Motors case. My daughters, Tanushree and Madhushree, and my colleagues, Dr. Charles Noon, Kitty Cornett, and Michael May, deserve thanks for patiently reading the manuscript and providing many helpful comments and suggestions. Thanks are also due to Judy Bass, Senior Editor at McGraw-Hill Professional, for her support throughout the entire project.

Finally, and most important, I would like to thank my wife, Kanchan, who showed a great deal of patience and understanding during the past 18 months that I have worked on this project. She has been a constant source of support and encouragement.

THE SIXTEEN LEAN SUPPLY CHAIN PRINCIPLES

Lean Supply Chain Principle 1

Improving the performance of every subsystem in isolation will not improve system performance. Improvements in subsystem performance must be gauged only through their impact on the whole system.

Lean Supply Chain Principle 2

Focus on improving the performance of the Lean supply chain—but do not ignore the supply chain's business ecosystem.

Lean Supply Chain Principle 3

Time lost at a bottleneck resource results in a loss of output for the whole enterprise (entire supply chain). Time saved at a nonbottleneck resource is a mirage.

Lean Supply Chain Principle 4

Decisions should be based on a throughput world perspective. While enterprises should try to increase throughput, decrease investment, and decrease operating expenses, the focus must be on improving throughput.

Lean Supply Chain Principle 5

Focus on customer needs and process considerations when designing the product. Enterprises can gain tremendous competitive advantage through best-in-class practices that cut across industries.

Lean Supply Chain Principle 6

Maximize external variety with minimal internal variety. It is desirable to maintain inventories in an undifferentiated form for as long as it is economically feasible to do so.

Lean Supply Chain Principle 7

The role of operations strategy is to provide the enterprise with the ability to cope with changing customer preferences. Products and processes should be designed to promote strategic flexibility.

Lean Supply Chain Principle 8

Buffer the variation in demand with capacity, not inventory.

Lean Supply Chain Principle 9

Develop partnerships and alliances with members of the supply chain strategically, with the goal of delivering goods and services as quickly and efficiently as possible.

Lean Supply Chain Principle 10

Formulate supply chain performance metrics that focus on improving throughput.

Lean Supply Chain Principle 11

Use forecasts to plan and pull to execute. A system that reacts to pull signals will have less variation than a comparable system that adopts a push mode of operation.

Lean Supply Chain Principle 12

Reduce variation in the system. Reduced variation allows the supply chain to operate with higher throughput, lower investment, and lower operating expense.

Lean Supply Chain Principle 13

Focus on bottleneck resources because they control the flow. Synchronize flow by first scheduling the bottleneck resources on the most productive products; and then schedule nonbottleneck resources to support the bottleneck resources.

Lean Supply Chain Principle 14

Do not focus on balancing capacities. Focus on synchronizing the flow.

Lean Supply Chain Principle 15

Focus on project completion times rather than task completion times. To ensure timely project completions, buffer the project, not the task.

Lean Supply Chain Principle 16

To reduce bad multitasking, let the bottleneck resource pace the release of projects into the system.

CONTENTS

Foreword	xv
Preface	xvii
Acknowledgments	xxi
The Sixteen Lean Supply Chain Principles	xxiii
CHAPTER 1	The Lean Supply Chain Roadmap..... 1
Challenges to the Lean Supply Chain	3
<i>The Internet and Commoditization.</i>	4
<i>Manufacturing Practices</i>	5
The Bullwhip Effect	6
<i>The Beer Game</i>	9
<i>The Impact of Forecasting and POS Data</i>	13
<i>The Impact of Lead Times</i>	15
<i>Lessons from the Beer Game.</i>	16
Structuring the Lean Supply Chain.....	19
The Lean Supply Chain Roadmap.....	21
<i>Step 1: Develop Systems Thinking Skills</i>	21
<i>Step 2: Focus on Throughput</i>	22
<i>Step 3: Design Products and Services that</i> <i>Deliver Customer Needs.</i>	23
<i>Step 4: Develop a Competitive Operations</i> <i>Strategy.</i>	24
<i>Step 5: Form Strategic Alliances with</i> <i>Supply Chain Partners</i>	24
<i>Step 6: Streamline the Value Stream</i>	25
<i>Step 7: Create Flow Along the Supply Chain.</i>	25
Implementing the Lean Supply Chain Roadmap.....	26
Conclusions	27
References	28

CHAPTER 2	Envisioning the Lean Supply Chain: Systems Thinking	31
	The Traditional Approach to Managing Systems.	31
	<i>Local Optimization</i>	32
	Using Systems Thinking to Meet the Challenge.	33
	<i>Applying Lean Supply Chain Principle 1</i>	34
	Management Philosophies to Enhance Lean	
	Supply Chain Performance	38
	<i>The Theory of Constraints</i>	38
	<i>Theory of Constraints and Un-common Sense</i>	41
	<i>Lean</i>	42
	Synergies Between TOC and Lean.	44
	The Business Ecosystem	47
	<i>Personal Computer Ecosystems</i>	51
	Conclusions.	60
	References	61
 CHAPTER 3	 Adopting a Throughput World Perspective	 63
	TOC and the Thinking Process	64
	<i>An Un-common Sense Minute</i>	65
	Focusing on the Constraint	66
	<i>Physical Constraints</i>	67
	<i>Market Constraints</i>	68
	<i>Policy Constraints</i>	68
	Estimating Product Costs with Cost	
	Accounting Systems	69
	<i>The Standard Cost Accounting System</i>	70
	CSN, Inc.	73
	<i>Activity-Based Costing (ABC)</i>	77
	<i>Applying ABC to CSN, Inc.</i>	79
	Throughput Accounting.	82
	<i>Throughput Accounting Measures</i>	82
	<i>Relating Throughput Accounting to</i>	
	<i>Traditional Accounting</i>	83
	<i>Kings of Neon</i>	85
	<i>Relating Throughput Accounting Measures</i>	
	<i>to Financial Measures</i>	87