Preface

Managers of production systems are well aware that to ensure high productivity they must:

- Identify, protect, and improve bottlenecks;
- Ensure leanness of work-in-process, raw materials, and finished goods inventory;
- Guarantee desired level of customer demand satisfaction in quantity and quality of products shipped.

But how can all of this be accomplished? This book provides a simple and practical answer to this question and offers software that facilitates applications. Methods described here use traditional terms, such as “bottlenecks”, “leanness”, “continuous improvement”, etc., but infuse them with rigorous engineering knowledge and, thereby, offer a possibility of designing and operating production systems with the highest efficiency and guaranteed performance. These methods are based on fundamental laws that have been discovered in the emerging field of Production Systems Engineering (PSE) and summarized, along with numerous industrial case studies, in our university-level textbook: J. Li and S.M. Meerkov, *Production Systems Engineering*, Springer, 2009 (below, we refer to this book as *PSE, Springer, 2009*). The goal of the current volume is to present these laws and methods in a format suitable for an industrial audience – without lengthy mathematical derivations but with logical justifications and emphasis on applications. That is why we use the title *Production Systems Engineering for Factory Floor Management* (PSE FFM) and view this volume as an industrial textbook. It can be used for either self-study or as a text for an industrial short course (2-3 days) on production systems management. The target audience includes plant, shop, and department managers; production supervisors; industrial, manufacturing, production, and quality engineers; production system designers; and supply chain specialists. Manufacturing team leaders and team members may also benefit from this book. As far as prerequisites are concerned, we believe that high school algebra and elementary statistics are sufficient to learn the techniques described here; an engineering degree would be helpful but not mandatory.

As a preview of what you will learn from this volume, answer the questions listed below. If you are not sure how to answer – don’t worry: even “manufacturing gurus” did not answer them! (That is why we use the subtitle “What manufacturing gurus did not teach you about managing production systems.”) After studying this textbook, you will be able to answer these questions with ease.

**Question 1:** In a serial production line with identical machines and identical buffers, which machine is the bottleneck? If the machines are not identical, is the worst machine necessarily the bottleneck?

**Question 2:** To maximize production system’s throughput, would you prefer machines with long or short up- and downtime, provided that their stand-alone throughput remains the same?
**Question 3:** To maximize the throughput, would you allocate work so that buffers are full, or empty, or neither? In the latter case, which buffer occupancy indicates that work is allocated optimally? Similarly, which buffer occupancy indicates the best buffer capacity allocation?

**Question 4:** How would you select lean buffering for a production system? For example, are buffers of capacity 1000 parts lean? How about a buffer of capacity 10?

**Question 5:** In a production system with parts transported on carriers, how would you select the number of carriers so that throughput is maximized?

As you will learn from this textbook, some of these questions can be answered without any measurements or calculations – just based on fundamental laws that govern production systems, such as laws of reversibility, monotonicity, and improvability. Others require measurements, typically, machines’ up- and downtime, or blockages and starvations, or buffers’ occupancy. Still others are based on both measurements and calculations. To assist calculations, we have created the **FFM Toolbox** (see [www.ProductionSystemsEngineering.com](http://www.ProductionSystemsEngineering.com)), which is an essential part of this textbook.

The outline of this volume is as follows: Preliminaries are included in Chapter 1; here standard types of production systems are described, unified terminology is established, and methods for performance analysis (using the FFM Toolbox) are discussed. Chapter 2 presents fundamental laws of production systems; these laws allow us to understand and predict the system’s behavior. Chapters 3-5 address issues of bottlenecks, leanness, and product quality, respectively; the methods described here allow managers to design continuous improvement project with guaranteed results. Production lines with carriers are analyzed in Chapter 6; here we show how one can manage the number of carriers in the system so that neither starvations nor blockages by carriers takes place. In Chapter 7, methods for mathematical modeling of production systems are discussed; these methods allow analysts to represent any production system by one of the standard types introduced in Chapter 1 and investigated in Chapters 2-6. Finally, Chapter 8 summarizes the results, and the Index and Glossary list the terms and abbreviations used throughout the book.

Each of these chapters begins with a motivation and overview. Then, methods related to the subject matter and the corresponding FFM Toolbox functions are discussed. Next, case studies are outlined. Finally, a set of problems is provided to be solved using, in most cases, the FFM Toolbox.

There are many other books on production systems management available on the market. What differentiates this one is the following:

- It is based on rigorous engineering principles and methods, rather than on “common sense” arguments. While common sense is necessary, it is hardly sufficient for designing and operating modern production systems. Indeed, nobody would claim that common sense is sufficient to design and operate a modern aircraft. Modern production systems are not less complex than aircraft and, likewise, cannot be designed and managed efficiently using only common sense. Experience shows that “common sense” in production systems is often wrong (but its proponents seem never to be in doubt)!
- It offers measurement-based methods for managing production systems, rather than recipes. Similar to a physician who cannot treat a patient without taking vital signs, a
manager cannot “treat” a production system without appropriate measurements. We show in this book that “vital signs” of a production system are, in most cases, frequencies and durations of machine blockages and starvations. Based on these measurements, one can efficiently determine daily managerial decisions and design continuous improvement projects with guaranteed results.

- Instead of the celebrated Toyota production system, in particular, “just-in-time operation”, it offers what we call “just-right operation”. Within this operation, no protective resources, such as work-in-process and finished goods inventories, are eliminated but, instead, maintained at a “just-right” level, i.e., a minimum level, which is necessary and sufficient to ensure desired performance from the point of view of throughput, customer demand satisfaction, etc.

- Finally, as indicated above, it is written as a textbook (with problems sets and associated software) directed explicitly to the industrial audience. It can also be used in business schools for students without undergraduate engineering background.

Thus, quantitative engineering principles and methods, measurement-based management, just-right operation, and a textbook style are distinguishing features of this volume.

This book is not an “easy read”: it requires concentration and practice (problem solving). The benefits, however, are that you would not have to manage your production system by “gut feelings” or argue your opinion “by persuasion”; hard engineering facts will be your arguments.

During the last twenty-five years, we have applied the methods described in this book to dozens of production systems in large, medium, and small manufacturing organizations. These include GM, Ford, Chrysler, Toyota, MillerCoors, Kraft Foods, Kroger, Lexmark, Subzero, Ruud Lighting, HellermannTyton, etc. Consistently, significant improvements in productivity, quality, and customer demand satisfaction have been obtained. Learning and using these methods, you will be able to do the same.
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Specifically, consider a production line and determine (either by measurements on the factory floor or by calculations) the probabilities (or frequencies) of blockage and starvation of each machine. Place BLi and STi under each machine as follows: STi. In the same manner a medical doctor cannot treat patients without taking their vital signs, production systems cannot be managed without appropriate measurements. This lecture shows that the most important “vital signs” of a production system are blockages and starvations. Based on this information, managers can exercise MBM “a rigorous way for achieving good performance of production systems. 4-43. 4.11. Lab: PSE Toolbox Function for BN-m and BN-b Identification.