Preface to the First Edition

This book is an outgrowth of an earlier text that appeared in 1999 under the title "Operations Scheduling with Applications in Manufacturing and Services", coauthored with Xiuli Chao from North Carolina State. This new version has been completely reorganized and expanded in several directions including new application areas and solution methods.

The application areas are divided into two parts: manufacturing applications and services applications. The book covers five areas in manufacturing, namely, project scheduling, job shop scheduling, scheduling of flexible assembly systems, economic lot scheduling, and planning and scheduling in supply chains. It covers four areas in services, namely, reservations and timetabling, tournament scheduling, planning and scheduling in transportation, and workforce scheduling. Of course, this selection does not represent all the applications of planning and scheduling in manufacturing and services. Some areas that have received a fair amount of attention in the literature, e.g., scheduling of robotic cells, have not been included. Scheduling problems in telecommunication and computer science have not been covered either.

It seems to be harder to write a good applications-oriented book than a good theory-oriented book. In the writing of this book one question came up regularly: what should be included and what should not be included? Some difficult decisions had to be made with regard to some of the material covered. For example, should this book discuss Johnson's rule, which minimizes the makespan in a two machine flow shop? Johnson's rule is described in virtually every scheduling book and even in many books on operations management. It is mathematically elegant; but it is not clear how important it is in practice. We finally concluded that it did not deserve so much attention in an applications-oriented book such as this one. However, we did incorporate it as an exercise in the chapter on job shop scheduling and ask the student to compare its performance to that of the well-known shifting bottleneck heuristic (which is one of the better known heuristics used in practice).

The fundamentals concerning the methodologies that are used in the application chapters are covered in the appendixes. They contain the basics of mathematical programming, dynamic programming, heuristics, and constraint programming.

It is not necessary to have a detailed knowledge of computational complexity in order to go through this book. However, at times some complexity terminology is used. That is, a scheduling problem may be referred to as polynomially solvable (i.e., easy) or as NP-hard (i.e., hard). However, we never go into any NP-hardness proofs.

Because of the diversity and the complexity of the models it turned out to be difficult to develop a notation that could be kept uniform throughout the book. A serious attempt has been made to maintain some consistency of notation. However, that has not always been possible (but, of course, within each chapter the notation is consistent). Another issue we had to deal with was the level of the mathematical notation used. We decided that we did have to adopt at times the set notation and use the $\in$ symbol. So $j \in S$ implies that job j belongs to a set of jobs called S and $S_1 \cup S_2$ denotes the union of the two sets S_1 and S_2.

The book comes with a CD-ROM that contains various sets of powerpoint slides. Five sets of slides were developed by instructors who had adopted the earlier version of this book, namely Erwin Hans and Johann Hurink at Twente University of Technology in the Netherlands, Siggi Olafsson at Iowa State, Sanja Petrovic in Nottingham, Sibel Salman at Carnegie-Mellon (Sibel is currently at Koç University in Turkey), and Cees Duin and Erik van der Sluis at the University of Amsterdam. Various collections of slides were also made available by several companies, including Alcan, Carmen Systems, Cybertec, Dash Optimization, Ilog, Multimodal, and SAP. Both Ilog and Dash Optimization provided a substantial amount of additional material in the form of software, minicases, and a movie. The CD-ROM contains also various planning and scheduling systems that have been developed in academia. The LEKIN system has been especially designed for the machine scheduling and job shop models discussed in Chapter 5. Other systems on the CD-ROM include a crew scheduling system, an employee scheduling system, and a timetabling system.

This new version has benefited enormously from numerous comments made by many colleagues. First of all, this text owes a lot to Xiuli Chao from North Carolina State; his comments have always been extremely useful. Many others have also gone through the manuscript and provided constructive criticisms. The list includes Ying-Ju Chen (NYU), Jacques Desrosiers (GERAD, Montreal), Thomas Dong (ILOG), Andreas Drexl (Kiel, Germany), John Fowler (Arizona), Guillermo Gallego (Columbia), Nicholas Hall (Ohio State), Jack Kanet (Clemson), Chung-Yee Lee (HKUST), Joseph Leung (NJIT), Haibing Li (NJIT), Irv Lustig (ILOG), Kirk Moehle (Maersk Line), Detlef Pabst (Arizona), Erik van der Sluis (University of Amsterdam), Marius Solomon (Northeastern University), Chelliah Sriskandarajah (UT Dallas), Michael Trick (Carnegie-Mellon), Reha Uzsoy (Purdue), Alkis Vazacopoulos (Dash Optimization), Nitin Verma (Dash Optimization), and Benjamin Yen (Hong Kong University).

The technical production of this book and CD-ROM would not have been possible without the help of Berna Sifonte and Adam Lewenberg. Thanks are also due to the National Science Foundation; without its support this project would not have been completed.

A website for this book will be maintained at

<div align="center">http://www.stern.nyu.edu/~mpinedo</div>

This site will keep an up-to-date list of the instructors who are using the book (including those who used the 1999 version). In addition, the site will contain relevant material that becomes available after the book has gone to press.

<div align="right">Michael Pinedo
New York, fall 2004</div>

Preface to the Second Edition

This second edition has undergone one major change and numerous minor changes. The major change involves a new chapter that focuses on planning and scheduling in health care.

Operations Research in health care has been a very hot topic over the last two decades and many researchers have begun focusing their attention on health care since it is such an important component of our GDP. Moreover, in health care there are planning and scheduling problems galore.

The book covers now exactly ten application areas, five in manufacturing and five in services (even though the borderline between manufacturing and services is often blurry).

The other chapters have undergone some minor changes as well. The changes involve a number of crossreferences, pointing out to the reader the relationships that models in one chapter have with models in another chapter.

This new version has again benefited enormously from numerous comments made by many colleagues. The list includes Detlef Pabst (Arizona), Erik van der Sluis (University of Amsterdam), ...

The technical production of this book and CD-ROM would again not have been possible without the help of Adam Lewenberg. Thanks are also due to the National Science Foundation; without its support this project would not have been completed.

A website for this book will continue to be maintained at

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This site will keep an up-to-date list of the instructors who are using the book (including those who used the 1999 and 2005 versions). In addition, the site will contain relevant material that becomes available after the book has gone to press.

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Michael Pinedo

New York, fall 2009

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