Real Optimization with SAP® APO. *By Josef Kallrath and Thomas I. Maindl.* Springer-Verlag, Berlin, 2006. $79.95. xxvi+321 pp., hardcover. ISBN 3-540-22561-7.

Producing and bringing products to market underlie the lifestyle in developed economies. It is easy for the lay person to overlook the complexities inherent in these processes. Such complexities include, but are not limited to, adjusting activities to ensure meeting demand while not exhausting raw materials, labor, or transportation possibilities, and, if demand can be satisfied, minimizing a cost or maximizing a profit. Adding to the complexities are multiple or conflicting product-specific goals, such as minimizing the changes over time in use of labor on assembly lines. Advanced software systems that integrate data acquisition, user interfaces, and mathematical ideas and algorithms for constraint satisfaction, local and global optimization are increasingly used. This book is about such *supply chain* problems and software.

The comment on the back jacket accurately describes readers who can clearly benefit from this book: "The authors address readers involved in optimization projects in which SAP and, particularly, SAP APO are implemented in companies. These are the project designers, project leaders, the ID personnel inside the companies, but also operations research practitioners, supply chain management consultants, and decision makers in the area of tool selection for optimization tasks." However, the authors, expert consultants in supply chain issues but also accomplished astrophysicists in academia, are in a position to provide relevance as well as precise language, mathematical perspective and clarity. This bridge between the academic and commercial can benefit both users of packages for supply chain planning and operations and academically oriented members of the mathematical optimization community.

The term "real optimization" in the title can refer to two things. First, it can refer to the process of finding an actual optimum of an objective function, as contrasted with merely producing a production or scheduling plan that satisfies requirements. Second, it can refer to the fact that the case studies involve real companies with implementations tailored to and being used in actual supply chain planning and operation.

SAP is a well-known corporation that provides general software and consulting for data acquisition and management, as well as software to compute feasible solutions and optimal solutions to supply chain problems. External companies and consulting services also supply interfaces to SAP products. "SAP APO" stands for "SAP Advanced Planning and Optimizer." Most of the book focuses on optimization and supply-chain issues in the context of SAP products, reasonable to do in view of those products' widespread use. Readers with a more general interest in applied optimization or supply chain problems can view the use of SAP APO in the entire book as one large case study.

The book is organized into four parts: an extensive introduction, detailed case studies, a summary section, and three appendices.

Part I: The Introduction

Chapter 1 gives an introduction to the business perspective of supply chain data acquisition and organization, including standardized terminology for supply chain and planning systems and a brief introduction to the components and structure of SAP APO.

Chapter 2 contains definitions of terms related to data models and optimization, and types of optimization problems (mixed integer linear programs, nonlinear programs, etc.). Problem representation in the data (the supply chain model as in SAP APO) and the mathematical model (in terms of variables, indices, objective, and constraints) are contrasted. The authors note that SAP allows definition of a model in supply chain terminology, but the automatic generation of objective and constraints is proprietary.

Chapters 3 and 4, containing numerous examples and screen shots, illustrate setting up and dealing with the model in SAP APO. For instance, the system can be instructed to treat mixed integer models as purely continuous models, etc. These are practical ways of conquering combinatorial complexity. The result is a feasible (although not necessarily globally optimal) solution obtained within a predictable computing time; the point is that this solution is both practical to obtain and valuable in actual supply chain planning and operation. A detailed derivation of a mathematical optimization problem from an example supply chain model (although hidden from the user in SAP APO) is also presented.

Part II: Detailed Case Studies

Chapters 5 through 9 contain case studies describing specific consulting (or application development) experiences, in candid detail. This includes interaction with the business client to determine goals and specifics of the application, thoughts on where and how human interaction with the software system best occurs, how well the packaged components in SAP APO fit the application, and when customized external solutions are more appropriate.

These case studies illustrate the importance of user-interfaces and user interaction. That is, deciding on an actual plan does not involve only a single pass of formulating a fixed model, running a global optimization, then using the result to dictate the business plan, but is an iterative process:

1. posing an initial model;

2. doing an optimization to compute an initial plan;

3. adjusting objective function weights and adding previously unidentified constraints to define business priorities and make the solution correspond more closely to reality;

4. repeating steps 1, 2, and 3.

Indeed, an important early part of the process is prioritizing different business objectives, which leads to different objective functions. Heuristics such as "minimize assembly line idle time" may be more practical to use than overall goals such as "maximize profit," and various overall goals may conflict. Often more

than one type of optimization is involved, with an initial approximation given, say, with a continuous linear program solution, and subsequent refinements done with mixed integer technology. The book provides details.

The specific case studies, in chapters 5 through 8, are from semiconductor manufacturing, consumer products, the automotive and chemical industries, and the process industry. Chapter 9, written by the external authors Rémi Lequette of ILOG corporation and Axel Hecker of Mathesis GmbH, describes models and implementations tailored to specific situations, and for which the intrinsic capabilities of SAP APO do not suffice.

Parts III and IV: Concluding Considerations and Appendices

The 20-page conclusion contains a summary of what users can expect from SAP APO, general thoughts on design and implementation of business supply chain software, and thoughts on the relationship of business software to ideas and techniques from the mathematical optimization community. It also contains general thoughts on what users can and cannot expect from SAP APO, how such users can increase their benefits by doing "real optimization" (as opposed to data management and finding a feasible plan), and how SAP might improve its "APO" product.

The first appendix, "The Hitchhiker's Guide to SAP APO," gives a brief introduction to the SAP APO components and SAP APO's hierarchical planning philosophy.

The second appendix, 20 pages, contains a succinct overview of "Mathematical Foundations of Optimization." The topics include linear programming (with sketches of the primal simplex algorithm and associated techniques, the dual simplex algorithm, and interior point methods) mixed integer linear programming, and multicriteria optimization and goal programming. (Mixed integer linear programming represents the predominant type of underlying mathematical optimization problem encountered in the book.)

The book includes a glossary, 104 references dealing with both mathematical and business issues, biographies of the authors, contains a seven-page index, and a list of acronyms and abbreviations.

Concluding Recommendations

I recommend this book for personnel in corporations and governmental entities contemplating improving supply chain operations with SAP software. The book may also be of more general interest to operations researchers and mathematical optimization professionals, especially those interested in mixed integer linear programs, those wanting to keep their academic activities relevant to real-world concerns, and those wishing to gain experience in commercial applications.