AIMMS Modeling Guide - Preface

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Preface

Three AIMMS *books*

The printed AIMMS documentation consists of three books

- AIMMS—*The User's Guide*,
- AIMMS—*The Language Reference*, and
- AIMMS—*Optimization Modeling*.

The first two books emphasize different aspects in the use of the AIMMS system, while the third book is a general introduction to optimization modeling. All books can be used independently.

Available online

In addition to the printed versions, these books are also available on-line in the ADOBE Portable Document Format (PDF). Although new printed versions of the documentation will become available with every new functional AIMMS release, small additions to the system and small changes in its functionality in between functional releases are always directly reflected in the online documentation, but not necessarily in the printed material. Therefore, the online versions of the AIMMS books that come with a particular version of the system should be considered as the authoritative documentation describing the functionality regarding that particular AIMMS version.

Release notes

Which changes and bug fixes are included in particular AIMMS releases are described in the associated release notes.

What is in the AIMMS documentation

The User's Guide

The AIMMS User's Guide provides a global overview of how to use the AIMMS system itself. It is aimed at application builders, and explores AIMMS' capabilities to help you create a model-based application in an easy and maintainable manner. The guide describes the various graphical tools that the AIMMS system offers for this task. It is divided into five parts.

- Part I—*Introduction to* AIMMS—what is AIMMS and how to use it.
- Part II—*Creating and Managing a Model*—how to create a new model in AIMMS or manage an existing model.
- Part III—*Creating an End-User Interface*—how to create an intuitive and interactive end-user interface around a working model formulation.

- Part IV—*Data Management*—how to work with cases and datasets.
- Part V—*Miscellaneous*—various other aspects of AIMMS which may be relevant when creating a model-based end-user application.

The Language Reference

The AIMMS Language Reference provides a complete description of the AIMMS modeling language, its underlying data structures and advanced language constructs. It is aimed at model builders only, and provides the ultimate reference to the model constructs that you can use to get the most out of your model formulations. The guide is divided into seven parts.

- Part I—*Preliminaries*—provides an introduction to, and overview of, the basic language concepts.
- Part II—*Nonprocedural Language Components*—describes AIMMS' basic data types, expressions, and evaluation structures.
- Part III—*Procedural Language Components*—describes AIMMS' capabilities to implement customized algorithms using various execution and flow control statements, as well as internal and external procedures and functions.
- Part IV—*Sparse Execution*—describes the fine details of the sparse execution engine underlying the AIMMS system.
- Part V—*Optimization Modeling Components*—describes the concepts of variables, constraints and mathematical programs required to specify an optimization model.
- Part VI—*Data Communication Components*—how to import and export data from various data sources, and create customized reports.
- Part VII—*Advanced Language Components*—describes various advanced language features, such as the use of units, modeling of time and communicating with the end-user.

Optimization Modeling

The book on optimization modeling provides not only an introduction to modeling but also a suite of worked examples. It is aimed at users who are new to modeling and those who have limited modeling experience. Both basic concepts and more advanced modeling techniques are discussed. The book is divided into five parts:

- Part I—*Introduction to Optimization Modeling*—covers what models are, where they come from, and how they are used.
- Part II—*General Optimization Modeling Tricks*—includes mathematical concepts and general modeling techniques.
- Part III—*Basic Optimization Modeling Applications*—builds on an understanding of general modeling principles and provides introductory application-specific examples of models and the modeling process.
- Part IV—*Intermediate Optimization Modeling Applications*—is similar to part III, but with examples that require more effort and analysis to construct the corresponding models.

- Part V—*Advanced Optimization Modeling Applications*—provides applications where mathematical concepts are required for the formulation and solution of the underlying models.

Documentation of deployment features

In addition to the three major AIMMS books, there are several separate documents describing various deployment features of the AIMMS software. They are:

- AIMMS—*The Function Reference*,
- AIMMS—*The COM Object User's Guide and Reference*,
- AIMMS—*The Excel Add-In User's Guide*, and
- AIMMS—*The Open Solver Interface User's Guide and Reference*.

These documents are only available in PDF format.

Help files

The AIMMS documentation is complemented with a number of help files that discuss the finer details of particular aspects of the AIMMS system. Help files are available to describe:

- the execution and solver options which you can set to globally influence the behavior of the AIMMS' execution engine,
- the finer details of working with the graphical modeling tools, and
- a complete description of the properties of end-user screens and the graphical data objects which you can use to influence the behavior and appearance of an end-user interface built around your model.

The AIMMS help files are both available as Windows help files, as well as in PDF format.

AIMMS *tutorials*

Two tutorials on AIMMS in PDF format provide you with some initial working knowledge of the system and its language. One tutorial is intended for beginning users, while the other is aimed at professional users of AIMMS.

Searching the documentation

As the entire AIMMS documentation is available in PDF format, you can use the search functionality of Acrobat Reader to search through all AIMMS documentation for the information you are looking for.

AIMMS *model library*

AIMMS comes with an extensive model library, which contains a variety of examples to illustrate simple and advanced applications containing particular aspects of both the language and the graphical user interface. You can find the AIMMS model library in the Examples directory in the AIMMS installation directory. The Examples directory also contains an AIMMS project providing an index to all examples, which you can use to search for examples that illustrate specific aspects of AIMMS.

What's in the Optimization Modeling guide

Introduction to optimization modeling

Part I—Introduction to Optimization Modeling—covers what models are, where they come from, and how they are used. This part is for anyone who is new to the area of optimization modeling.

- Chapter 1. "Background," gives background information on optimization modeling, and highlights the process from a real life problem to a well-posed problem statement.
- Chapter 2. "Formulating Optimization Models," lays the foundation for all chapters that follow. It gives an overview of linearly constrained optimization models and their characteristics. These models are then extended to include integer and nonlinear constraints.
- Chapter 3. "Algebraic Representation of Models," compares different formulations of the same model, and introduces the fundamental concept of *index notation*.
- Chapter 4. "Sensitivity Analysis," gives an extensive introduction to the use of *marginal values* for sensitivity analysis.
- Chapter 5. "Network Flow Models," describes classes of network flow models as well as a example network formulation in AIMMS.

General optimization modeling tricks

Part II—General Optimization Modeling Tricks—includes mathematical concepts and modeling tricks for linear and mixed-integer linear programming.

- Chapter 6. "Linear Programming Tricks," provides some standard formulation tricks for linear programming.
- Chapter 7. "Integer Linear Programming Tricks," describes some standard formulation tricks for mixed-integer linear programming, and introduces the concept of Special Ordered Sets.

Basic optimization modeling applications

Part III—Basic Optimization Modeling Applications—builds on an understanding of general modeling principles and gives introductory application-specific examples of models and the modeling process.

- Chapter 8. "An Employee Training Problem," comes from an application for hiring and training new flight attendants and incorporates a *heuristic* for rounding a continuous solution into an integer-valued solution.
- Chapter 9. "A Media Selection Problem," comes from an application for deciding how best to market a product based on demographic data and contains examples of modeling *logical conditions* and *set covering, packing, and partitioning*.
- Chapter 10. "A Diet Problem," comes from an application for planning a healthy and inexpensive diet. The model shows how to use *units* and to *change the formulation* of a linear program into a mixed-integer program.
- Chapter 11. "A Farm Planning Problem," comes from an application for farm management and illustrates the use of *units*.

- Chapter 12. "A Pooling Problem, " comes from an application in which final products are blended from intermediate products to meet various quality specifications. Both *linear and nonlinear blending rules* are introduced.

Intermediate optimization modeling applications

Part IV—Intermediate Optimization Modeling Applications—similar to part III, but with examples that require extra effort and analysis to construct the corresponding models.

- Chapter 13. "A Performance Assessment Problem," comes from an application for *evaluating the performance* of several comparable organizations. The chapter illustrates a step-wise approach to determine efficient decision making units.
- Chapter 14. "A Two-Level Decision Problem, " comes from an application in which waste water *regulations* are *enforced through taxes and subsidies*. Both an iterative approach and a single-step approach using marginal values are used to solve the problem.
- Chapter 15. "A Frequency Allocation Problem, " concerns the *assignment* of frequency intervals to links in a communication system while *minimizing total interference*. Two formulations are discussed in detail.
- Chapter 16. "A Power System Expansion Problem," comes from the electric power industry and provides an overview of several approaches to uncertainty, namely *what-if analysis*, *two-stage stochastic programming* and *robust optimization*.
- Chapter 17. "An Inventory Control Problem," comes from an application for storing enough beer to meet uncertain demand. The demand is time dependent, and the model is formulated as a *multi-stage stochastic model*.

Advanced optimization modeling applications

Part V—Advanced Optimization Modeling Applications—provides applications where mathematical concepts are required for the formulation and solution of the underlying models.

- Chapter 18. "A Portfolio Selection Problem," comes from a financial application in which both *strategic* and *tactical investment* decisions are made. One-side variance is used as a measure of *portfolio risk*.
- Chapter 19. "A File Merge Problem," comes from a database application in which two large *statistical data files* are *merged* into one single file. The corresponding model is formulated as a network model for which *columns are evaluated* as needed.
- Chapter 20. "A Cutting Stock Problem," comes from an application in which large raws of paper and textile are sliced into patterns. *Patterns are generated* by an auxiliary model during the solution process, which makes this chapter a first introduction to *column generation*.
- Chapter 21. "A Telecommunication Network Problem," comes from an application in telecommunication network design with a focus on *bot-*

tleneck capacity identification. Again, a *column generation* technique is used to generate paths through the network.

- Chapter 22. "A Facility Location Problem," comes from a multi-commodity transportation application and implements a *Benders' decomposition algorithm* to solve the problem.

Preliminaries

Before you begin, you should be familiar with mathematical notation. This should be sufficient to read Parts I and III. Basic linear algebra and probability analysis is required for Parts II and IV. An introductory course in mathematical programming is recommended before reading the advanced chapters in Part V.

The authors

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Johannes Bisschop received his Ph.D. in Mathematical Sciences from the Johns Hopkins University in Baltimore USA in 1974. From 1975 to 1980 he worked as a Researcher in the Development Research Center of the World Bank in Washington DC, USA. In 1980 he returned to The Netherlands and accepted a position as a Research Mathematician at Shell Research in Amsterdam. After some years he also accepted a second part-time position as a full professor in the Applied Mathematics Department at the Technical University of Twente. From 1989 to 2003 he combined his part-time position at the University with managing Paragon Decision Technology B.V. and the continuing development of AIMMS. From 2003 to 2005 he held the position of president of Paragon Decision Technology B.V. His main interests are in the areas of computational optimization and modeling.

Other contributors to AIMMS

In addition to the main authors, various current and former employees of AIMMS B.V. (formerly known as Paragon Decision Technology B.V.) and external consultants have made a contribution to the AIMMS documentation. They are (in alphabetical order):

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