

# FUNDAMENTALS OF TRANSPORTATION AND TRAFFIC OPERATIONS

By Carlos F. Daganzo

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## PREFACE

This book is an attempt to present in a self-contained way those basic concepts in the transportation and traffic operations field that should be well understood by every transportation professional. This includes graduate students planning to pursue more advanced studies, as well as newcomers to the field who may be readying themselves for an in depth review of the literature. It is also hoped that academics will find parts of this book suitable for teaching material and/or reading assignments.

The book has evolved from a set of course notes that were prepared for an introductory graduate course in transportation operations currently taught in the transportation engineering division at UC Berkeley. The goal of this course is to introduce the basics of transportation operations to a wide cross-section of graduate students entering our interdisciplinary program, with backgrounds in civil engineering, city planning, operations research, economics, etc.

The structure and level of the book, as that of the course, is dictated by the necessity to reach such a wide audience in a pedagogically sensible manner. For example, probabilistic concepts are avoided to the extent possible until chapter 6 in order to allow some students to take a concurrent course on probability theory. Elementary calculus concepts, however, are used from the beginning. It is also assumed that the reader has the basic modeling skills that one would develop in an introductory physics course. An effort has been made to represent different things by different symbols within each chapter, and to use a unique symbol for the most important variables used throughout the book. Notational inconsistencies across chapters could not be totally avoided, however, due to the variety of subjects.

The book has chapters on tools (1, 2, 3, and the first part of 6) and others on applications (4, 5, 2nd part of 6, and 7). Very brief introductions to graphical methods, optimization, probability, stochastic processes, statistics and simulation are provided as part of the "tool" chapters. Somewhat unorthodox, these discussions have been made as self-contained as possible, emphasizing the most useful aspects of each tool. This is not the emphasis one usually finds in more specialized books. Readers already familiar with these subjects may skip chapter 3 and the first two sections of chapter 6, although they may find some portions of the discussion entertaining. Chapters 1 and 2 should not be skipped, however.

The book covers some of the application topics in more depth than would be necessary for an introduction in order to fill gaps in the existing literature. Most notably, "Fundamentals" includes a fairly detailed treatment of "traffic flow theory" in Chaps. 1, 2 and 4. The second half of Chap. 4, covering "traffic dynamics," are more demanding than the rest of the book, but this was necessary for the sake of completeness. A more detailed treatment of this subtle topic is

included because certain aspects of it are repeatedly missinterpreted in the published literature. The presentation of this topic stresses the simple traffic theories introduced in the fifties, whose successes and drawbacks are well understood, and ignores modern refinements which have not stood serious scrutiny.

The remaining application topics, "control" (Chap. 5), "observation" (2nd part of Chap. 6) and "scheduled modes" (Chap. 7), use a "building block" approach. Basic ideas involving simple systems (e.g., the timing of a simple traffic signal, the estimation of a bottleneck's "capacity," and the evaluation of passenger delay at a bus stop) are presented in detail and more complicated ones (e.g., networks, estimation of an origin-destination table, and coordination of transit schedules) more qualitatively. An objective was to present the issues clearly, more than a list of specific techniques. As with the material on traffic flow theory, an effort has been made to point out various pitfalls so that they can be avoided. Here too, only that material which is definitely known and correct has been presented in the hope that a newcomer to the transportation field will find in this book a useful source of basic culture.

The application subjects included do not represent a complete survey of those topics one could characterize as "transportation operations" because the book deemphasizes the description of facts (which change as technology changes) in favor of logic. Furthermore, only logical ideas which in my opinion have a solid grounding in physical reality have been included because those are the ones that have the best chance of standing the test of time. This seems appropriate for an introductory book (course) that attempts to prepare the reader for a critical understanding of the field. Of course, many excluded topics deserve treatment in journals and in more specialized books/courses. The reader should turn to these for proper coverage of the current literature.

"Fundamentals of transportation and traffic operations" may be used as a textbook if complemented with problems. A set of solved problems jointly developed with UC Berkeley colleagues will be available in the near future and can be ordered by writing to: Institute of Transportation Studies, Publications Office, 109 McLaughlin Hall, University of California, Berkeley, CA 94720; or sending e-mail to [itspubs@violet.berkeley.edu](mailto:itspubs@violet.berkeley.edu). The book can also be used as background reading in graduate and undergraduate courses on transportation and traffic operations. "Fundamentals" also describes a number of computer spreadsheets that can be used for various purposes, including class demonstrations. These can be downloaded from the INTERNET by looking up the book title at <http://www.ce.berkeley.edu/~daganzo> and following instructions.

I would be interested in learning of any errors, and plan to issue an errata sheet in conjunction with the set of problems when/if significant ones are found; the errata will also be posted on the INTERNET. Comments may be sent by email to [daganzo@ce.berkeley.edu](mailto:daganzo@ce.berkeley.edu).

I wish to thank my mentor and colleague Gordon F. Newell for his valued comments, both on the course and on the book. Professor Rod Troutbeck of Queensland University of Technology, Brisbane, Australia, hosted me graciously during a sabbatical leave which made possible preparation of a first draft. His comments and encouragement are also deeply appreciated; the title of the book was suggested by him. Thanks are also due to Prof. Mike Cassidy of UC Berkeley for furnishing valuable feedback on those portions of the book he has used in the classroom, to Mrs. Ping Hale for patiently putting up with me while preparing a first draft of the manuscript and to Ms. Esther Kerkmann for doing the graphics. A grant from the University of

California Transportation Center made it all possible. Most of all, however, I want to thank my wife, friend and companion, Valery, for her support and understanding.

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December 29, 1996

