

# Transportation Planning

## 交通规划

王元庆 马书红 编著

Wang Yuanqing Ma Shuhong



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# Preamble

For new transportation planners who have ever taken transportation planning courses, they typically realize that the challenges in practice are much more complex than what they met in learning transportation planning textbooks; unable to clearly understand the unsustainability of the dependence of human on cars and do not know the standard of a good planning, leading to more traffic congestions and more serious urban traffic pollution; know few about the computer programming needed in transportation modeling thus feel hard to get started to develop transportation models; unable to effectively evaluate the reliability of the output from planning models thus hard to know the future traffic trends and identify core problems in planning areas; fail to select reasonable indices that can be used to evaluate the effect of problem-solving for different planning scenarios; and unable to appropriately integrate new and old planning techniques in planning design.

To the above challenges in transportation planning classes, the authors have been devoting to the improvements of contents and modes in transportation planning class teaching since 1990. In addition, the authors have actively participated in high-level research and consulting activities with multiple objectives and multiple levels in the field of transportation planning, and have finished many research projects at national

level, such as projects from Ministry of Education, Ministry of Transport, and National Natural Science Foundation of China. The authors have also worked on many research and consulting projects funded by international agencies, including the World Bank, the Asian Development Bank, the American Energy Foundation, the Reason Foundation, and the Australian Research Foundation.

What is more, the authors have conducted multi-modal transportation planning for many regions, including the provinces of Shaanxi, Liaoning, Zhejiang, Guangdong, Hebei and the cities of Xi'an, Ningbo, Guangzhou; their proposed plans have been highly evaluated and well implemented in these regions.

After 20 years of continuous efforts, the transportation planning course has obtained fruitful achievements. The authors have worked with more than 200 graduate students and nearly 1000 undergraduate students to explore how to efficiently learn the key knowledge and skills needed in transportation planning, at the same time, to help establish a solid and diversified knowledge and methodology system for students to work in different areas in the future, such as research, consulting, decision-making, management, technology development, large-data mining and investment evaluation.

The course has been supported by the Ministry of Education, Education Department of Shaanxi Provincial Government, and Chang'an University in China. It has been granted the National Bilingual Teaching Demonstration Course, the Shaanxi Province Excellent Course and the Shaanxi Province Excellent Resources Sharing Class (<http://jiaotonghuihua.chd.edu.cn/>). It has received a large number of reading online from various sectors of society and won the Second Prize of Teaching Achievement in Shaanxi Province, the First Prize of Transportation Education Science Excellent Achievement Award of China Transportation Education Research Association and the Third Prize of the Seventh Higher Education Scientific Research Achievement Award in Shaanxi Province. This course collaborated with the iCourse in 2017, which allows readers to learn the course online (<http://www.icourses.cn/home/>).

Compared with other transportation planning textbooks, this textbook strengthens the contents on transportation system and its characteristics, regional transportation

models, model calibration and renewal, development of planning scenarios, index system of scenario evaluation and whole life-cycle cost analysis, which are in great demand but used to be overlooked. In addition, this textbook chooses the Cube software, which has a strong structure and is easy to apply multi-iteration molding, as a practical transportation model platform during the tutorial. The Cube's modeling idea, calculation parameters and data flow organization can also be used as reference for other transportation planning software packages. To improve students' thinking and application skills, the textbook adds a large number of practical examples based on the authors' practice, including many examples of practical applications. In view of an increasing importance of movement analysis (OD or PA analysis) in recent years in urban or regional planning, rail roads, public transit, urban design and large data calculation, the authors applied the "0 basis" concept in the book writing to make it easy for readers to learn.

The completion of the book gained support and help from many predecessors and friends in transportation field. Thanks to Prof. Wang Binggang (Chang'an University), Mr. Zhou Wei (Ministry of Transport), Ms. Sun Xiaoduan (University of Louisiana), Mr. Sam Zimmermans (World Bank) and Mr. Wang Quanlu (Argonne National Laboratory in the United States) for providing directions to the authors of this book. Thanks to Prof. Wang Wei (Southeast University) Prof. Yang Xiaoguang (Tongji University) Prof. Liu Xiaoming (Ministry of Transport), Prof. Lu Huapu (Tsinghua University) Prof. Shao Chunfu (Beijing Jiaotong University), Prof. Chen Yinsan (Chang'an University) and Prof. Wu Qiongqi (Chang'an University) for enlightening the authors from the beginning of their carrier.

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# Preface

Transportation Planning is a compulsory course of transportation engineering. It is one of the professional skills that a transportation planner needs to master. It has its own basic theory, also is integrated with a variety of basic curriculum knowledge, mainly including transportation engineering, civil engineering ( roads, bridges, construction ), economics, mathematics, systems engineering and computer applications. It is a comprehensive subject which integrates theory and practice; and the areas of learners engaging are diversified.

This book has 12 chapters, the contents in each chapter are presented as follows:

Chapter 1 introduces the background, development, and basic concepts of transportation planning, and discusses the location, composition and characteristics of transportation system.

Chapter 2 describes the types of transportation data, collection methods, commonly-used analytical methods and software packages, and some new data collection and processing methods.

Chapter 3 discusses the concept, structure, and classification of transportation model. It focuses on the basic principles of the Four-stage model and some typical transportation models.

Chapters 4 to 7 introduce the Four-stage model, namely trip generation, trip distribution, model split, and trip assignment. This is the core and key part of transportation planning theory. Each chapter narrates the basic principle and operation method of one step.

Chapter 8 talks about the contents of model calibration and validation.

Chapter 9 introduces the process and layout method of public transportation network planning, and the basic contents of public transportation facilities planning, which involve public transportation model modeling and public transportation service index calculation.

Chapter 10 presents several common methods of the generation of planning scheme from the aspects of regional network arrangement, urban center road network layout and urban new area planning.

Chapter 11 systematically introduces the whole life-cycle calculation method for planning project construction, including the basic methods and related cases of whole life analysis and evaluation, and also explains the basic principles and steps of game theory and Monte Carlo simulation to provide a reference for planning scheme choose.

Chapter 12 discusses the common indexes of different transportation planning schemes and the common methods of multi-index comparison. Readers can expand reading on the basis of the introduction of this chapter and study the transportation evaluation technology deeply.

In addition to basic theories, this book also provides a large number of planning practice examples from the author's planning practice and academic research to make the book easier for readers to understand.

Wang Guangming      Ma Shuhong

October, 2017

# Author Introduction

## **Wang Yuanqing**

Prof. Wang is a Level-II Professor in the School of Highway at Chang'an University. He is the Director of Transportation Research Institute and the BRT Research Center of School of Highway. He has finished several teaching reform projects, such as the Shaanxi Province Innovation Experiment Area of Transportation Engineering Personnel Training Mode and the National Bilingual Teaching Demonstration Course of Transportation Planning. He has won the award of New Century Talents of Ministry of Education and Young Teacher Program of Huo Yingdong, as well as more than a dozen awards from the China Highway and Transportation Society, Shaanxi Province, Guangdong Province and Zhejiang Province. Focusing on transportation behavior research and theoretical research on quantitative analysis technology, Prof. Wang has successfully applied his research in transportation planning, public transport improvement, low-carbon transportation, transportation design optimization and intellectualization. He has completed more than 100 research projects, and published more than 160 academic papers and books, including 12 SCI-indexed papers, 36 EI-indexed papers, and 5 books.

## **Ma Shuhong**

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In recent years, she has taught several transportation courses, including “Transportation Engineering” “Parking Planning and Designing” “Transport Hub and Static Transportation Facilities Design”, and “Transportation Planning Principle”. Since 2002, she has been engaged in research work on transportation planning, transportation economy, and transportation safety. She has published more than 30 SCI-indexed, EI-indexed, CSSCI-indexed or CSCD-indexed papers, and completed more than 10 research projects. Her research areas include highway network planning and evaluation, transportation economy, and policy research.

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# Introduction

## 1.1 Overview

### 1.1.1 Transportation System is a Complex System

A complex system is a system composed of many components which may interact with each other to achieve a certain purpose through mutual restraint. It is an approach to study how the changes of system components lead to the variation of the whole system, and how the system interacts with its environment. The studying approach of a complex system provides reference for transportation planning which is concerned with the multi-factor interaction and developed rapidly since 1960.

There are three aspects of modern complex system research: a. How the interaction causes a change in the mode of behavior; b. The possibility of changes; c. The formation and evolution of complex systems. There are five characteristics of transportation systems:

- Adaptive/self-organizing. The system is composed of various components which have the ability of self-adaptation, self-learning and self-organization. The components can adjust their behavior and structure through self-learning to adapt to external and internal changes. The traffic