时代教育·国外高校优秀教材精选

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Introduction to Traffic Engineering

A Manual for Data Collection and Analysis

交通工程入门

——数据采集与分析手册

英汉双语版·原书第2版

[美] 托马斯 R. 柯林 (Thomas R. Currin) 著

金治富 译

机械工业出版社
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本书主要阐述了地点速度、转向交通量统计、车辆延误、停车、饱和流率、泊松分布、排队长度、车头时距、交通守法率、高速公路交通密度、车辆乘载率、出行分布和出行生成等常规交通调查的内容及其方法。本书的最大特点是为人们提供了浅显易懂、便于操作的交通数据采集与分析方法。

本书可作为道路交通调查实践指导书，适用于我国高等学校交通运输规划与管理、交通工程等专业学生开展交通调查实践活动，也适用于广大交通工程技术人员在从事道路交通组织优化、道路交通现状评价等工作中进行初步的数据采集与分析。

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Thomas R. Currin

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About the Author

After completion of his undergraduate civil engineering degree at University of Massachusetts—Dartmouth in 1972, Thomas R. Currin honorably served in the United States Army. This was followed by enrollment in graduate school and completion of a Master of Civil Engineering program at North Carolina State University—Raleigh. He then obtained a Doctor of Philosophy in civil engineering specializing in traffic engineering from the University of Connecticut and obtained professional engineering licenses in a number of states including Massachusetts and Georgia.

Tom knew he wanted to teach engineering as early as his sophomore year in college. He was so convinced of this that in addition to taking the required engineering courses he successfully completed many courses in secondary education and studied various teaching methodologies and philosophies. Knowing that it would be difficult to teach what one had not done, he embarked on an extremely successful consulting engineering career, which included the analysis and design of numerous transportation projects throughout New England and the east coast.

Having achieved his goals in the private sector, Tom moved on to academia and preparing the next generation of engineers. While teaching, he has served as an evaluator and commissioner of ABET, the primary accreditation agency for engineering in the United States. The author of numerous engineering education publications and presentations since beginning his teaching career 23 years ago, his current focus as Dean of Engineering at Southern Polytechnic State University in Georgia is growing new engineering programs.

作者简介

1972年，托马斯 R. 柯林在完成马萨诸塞大学达特茅斯分校的土木工程专业本科学业之后，光荣地去美国军队服役。其后，他进入北卡罗来纳州立大学（罗利市）研究生院学习并获得了土木工程专业硕士学位。之后，他获得了康涅狄格大学土木工程专业交通工程方向的哲学博士，并获得了包括马萨诸塞州和佐治亚州在内的许多州的专业工程许可证。

早在大学二年级时，托马斯就想讲授工程学。正因为如此，他除了完成必修的工程学课程以外，还成功地修完了第二学位教育学的许多课程，并且研究各种教学方法与哲学。要知道，自己从没有做过工程学方面的业务，要想讲授该课程是很困难的。他从事了整个新英格兰地区和东海岸许多交通项目的设计与分析，他的工程生涯极为成功。

托马斯在私营企业达到了他的目标后转向学术界，并准备成为下一代工程师。他在教学的同时，还作为美国工程界主要认证机构 ABET 的一名评估师和理事从事相关工作。在23年的教学生涯中，他编写了大量工程教育出版物与学术报告。他作为佐治亚州的南方理工州立大学工程系主任，正关注着越来越多的新工程学课程。

译者前言

交通数据采集与分析是高等学校交通工程学课程的主要教学内容之一，是进行交通特征分析、交通运行状态评估、交通运行管理以及交通安全管理不可缺少的环节。交通工程专业的本科学生，必须掌握交通数据采集方法与分析方法，才能基于交通工程理论进行现实交通问题研究。围绕交通数据采集与分析方法的教学活动，属于实践教学活动，应当注重实际操作，不宜过于探究理论深度。为学生提供一本类似操作手册式的指南，使学生凭借这个指南就能够独立自主地进行交通参数的数据采集与分析，是非常必要的。

由美国托马斯 R. 柯林先生编写的《交通工程入门——数据采集与分析手册》（第 2 版），就像一本仪器操作手册，为初次接触交通工程学知识的读者带来了福音。该手册在很多情形下不要求配备特种专业设备和专业分析软件，人们日常生活中常用器具就可充当数据采集工具，使得数据采集简单易行，分析方法也易于理解。译者有多年的实践教学经验，相信这本书有助于学生轻松地完成常用交通参数的数据采集与分析工作。

本书共有 14 章，第 1 章为序言，第 2 章至第 14 章介绍了各种常用交通数据的采集与分析方法。其中，第 3、4、6、7、8、9 章分别介绍了交通量、车辆延误、饱和流率、泊松分布、排队长度、车头时距等常用交通参数或典型交通流特征的数据采集与分析方法，主要用于交叉口交通运行状况评价。从本书篇幅上看，关于交叉口交通运行状况评价的交通数据采集与分析方面的内容较多。译者认为，我国交通工程专业学生从事交通数据采集与分析的实践活动，也多着眼于交叉口交通运行状况的分析或评价，因此，这本书的知识结构设计是符合我国学生的实际需要的。第 2、11 章分别介绍了地点速度调查与高速公路交通密度调查。第 5、10、12 章分别介绍了停车调查、交通守法率调查和车辆乘载率调查。第 13、14 章主要介绍了出行生成与出行分布方面的调查。

原书第 2 版比第 1 版更为完善。同时，为方便交通类专业双语教学的实施，本书采用了英汉双语版的编排模式。机械工业出版社对本书的中文翻译给予了大力支持，并为本书的出版工作做出了不懈努力，在此表示衷心的感谢。尽管译者力求精准地反映原书内容，但是由于水平和时间有限，翻译中还会存在一些缺点和错误，敬请读者批评指正。

译　者

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1 Introduction

How to Use This Manual

Seeing is believing as the saying goes, and such is the case with traffic engineering. Observation of real drivers in real situations has always been the basis for this form of engineering and continues to this day. Research leading to the continuous improvement of traffic analysis techniques depends on the ongoing collection of data relating to driver behavior. As people change, so do their transportation needs. These changes are reflected in collected data, which allow transportation engineers to refine the transportation system to meet the existing mobility desires of society as well as anticipated future needs. Without quality data collection and appropriate analysis, the transportation engineer cannot accomplish this task.

This manual is meant to aid both the student of traffic engineering and the transportation engineering professional in sound data collection and analysis techniques. It presents step-by-step techniques for several traffic engineering topics. These include common studies—such as spot speeds, turning movements, and saturation flow rate. Also, newer topics—such as control delay and platoon ratio—are covered. The manual is best used in conjunction with a transportation engineering textbook.

The studies are organized to facilitate inclusion in a formal transportation engineering report. Each study follows a conventional format: topic introduction, equipment needed, step-by-step procedures, and step-by-step analyses. Data-collection and data-analysis forms are provided for each. These are included to aid the reader in accomplishing the work and may be removed from the manual for use as part of a report. Questions are included which form the foundation of the analysis and conclusions sections of a formal report.

In each case, real-world scenarios show where the study may be implemented and its contribution to the overall analysis of the situation. For example, the chapter on queue length analyzes drive-in windows at fast-food restaurants. It shows how the techniques can be applied to other facilities, such as drive-in banks. Standard equations show linkages between field data collection and estimation of field conditions. Such linkages allow the student of traffic engineering to see how the estimation equations were developed and how they compare to

an observed set of data. Also, it will become evident to the student that such linkages have limits to their forecasting capabilities.

The traffic engineering professional will find that this manual provides a structured format for an assortment of traffic engineering studies—along with examples of how these studies are used. The manual focuses on topics most likely to be needed when performing a traffic impact study. Consequently, some transportation planning topics are included—such as origin-destination and trip generation. Traffic accident analysis is not included in this manual, since the ability to collect and analyze data related to accidents often depends on local needs and regional right-to-privacy policies. When assigning data collection tasks to others, the procedure and data collection forms for the studies will help organize the data. Also, the analysis forms and procedure for analysis will ensure that important items are not overlooked.

The statistical analysis procedures presented in each study and in the Appendix are not meant to be a substitute for a formal study of statistics and related subjects. With traffic engineering professionals basing so many decisions on data collected and analyzed by themselves or others, it is imperative that probability, statistics, and numerical methods be part of their formal education. The material relating to these subjects in the chapters and the Appendix is presented as a refresher, not as a substitute. Those readers who have not had formal training in statistical analysis should use this manual under the guidance of a trained instructor or supervisor.

To the Instructor

Instructors wishing to use this manual as part of a course should note that the depth and breadth of coverage of each topic has been limited to the acquisition of data and its analysis. Leading textbooks used for the course will address each of the topics in much greater detail than space allows in this manual. They will provide the student with insight into other possible techniques, a more detailed explanation as to why the data is needed, and how the topic fits into the "big picture."

Each study has been class tested in a full-semester, transportation-engineering course. Each procedure can be accomplished by undergraduate engineering students within a reasonable amount of time and with proper understanding of the material. Given the sample sizes specified and the judicious choice of study location, the data-collection portion of each study can be completed within two hours, or less, in the field. The sample sizes assume three or four students per group, with all group members participating in the data-collection phase of the study.

Instructors need to consider whether or not to have their students interacting with moving traffic. Safety is always a concern—for the professional or the student—when working in the field. Students should be reminded to stay well away from the edge of the roadway when collecting information. The author's experience has shown the value of assigning one student responsibility for the safety of the group in the field. Others may wish to employ this technique as well. Safety during data collection cannot be over emphasized and should be closely monitored throughout the course.

As an alternative, the instructor may consider other ways for the students to collect the data if field work is deemed to be too risky. Many alternate data sources are available and can be used successfully. A good student exercise is to

have the students research sources of live video on the internet. One source is live video available from state transportation departments' websites. The Georgia Department of Transportation maintains numerous live traffic-monitoring cameras throughout the state from which data for nearly all the studies presented in this manual can be obtained.

Another data source is a traffic video library such as the one available on the Cengage Learning website, cengage.com/engineering. Using inexpensive video recorders, faculty or student workers can create a library of videos, which can simulate field data acquisition. These recordings need not be created by actual field visits but can be developed through the use of ongoing video traffic monitoring already in place as part of a city's intelligent transportation system. Viewing the traffic in this manner can facilitate in-class data collection, regardless of class size or weather conditions.

Yet another source of data is the practicing professional. Many local traffic engineers are pleased to share data for educational purposes. State and local departments of transportation are a good source as well. The data obtained from these sources usually has special meaning to the students, since it will likely relate to familiar roadways and intersections. In this case, the students will not be conducting the data-collection part of the studies—only the data analysis.

Finally, instructors are encouraged to supplement the content of this manual with their own real-world experiences. Refinement of the procedures to satisfy local conditions and regional needs will increase the students' interest in the quality of data acquired and analyzed.

Introduction to the Second Edition

The Second Edition is the result of a re-examination of the need for and the content of the original manuscript for its timeliness, breadth, and depth. The techniques presented in each chapter have been reviewed and verified for their validity and where needed modified to reflect present day practice or simply for clarity.

As previously mentioned this manual is designed to complement a transportation or traffic engineering textbook and extend the student's knowledge beyond that obtained in lecture only classes. Whether used at the time the course/s are taken or subsequently by the professional in the field who needs to collect data or direct others to collect data, the manual assumes the user has studied traffic engineering, as well as probability and statistics, and possesses a basic knowledge in the field.

As technology advances so should the methodology for acquiring traffic data. In the previous introduction several alternate methods for obtaining traffic data were identified including the use of traffic video libraries and live traffic monitoring equipment. In this new edition these areas are explored in more depth and some new items have been provided on the publisher's website or contained herein. They are:

- Updates of the analysis methods to conform with the latest version of the Highway Capacity manual
- New "Headway Study" chapter addressing the new basis for determining the quality of flow at an intersection

- New Freeway Density chapter dealing with the collection of data needed to compute traffic density on roadways having few intersections
- Pre-recorded traffic video recorded from the data collector's vantage point
- A list of traffic monitoring sites providing imagery of traffic suitable for data collection purposes
- Spreadsheet templates suitable for use in collecting traffic data
- Analysis templates suitable for downloading and use for data analysis

To access additional course materials, please visit www.cengagebrain.com. At the cengagebrain.com home page, search for the ISBN of your title (from the back cover of your book) using the search box at the top of the page. This will take you to the product page where these resources can be found.

Thank you to those who found the first edition useful. It is your valuable feedback and support which has lead to the second edition. In particular I would like to thank the following people who provided detailed reviews and suggestions:

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Mitsuru Saito, Brigham Young University

第1章

序　言

怎样使用本手册

眼见为实，交通工程也是如此。在真实情景下对真实驾驶人进行观察，一直以来是交通工程学的基础，并且持续到现在。旨在不断改进交通分析技术的研究，取决于不断发展中的驾驶行为数据采集技术。随着人们的变化，他们的交通需求也会发生变化。这些变化反映在采集的数据中，使交通工程师去改造交通系统成为可能，以满足社会对当前机动性（通畅性）的愿望以及对未来需求的预测。没有高质量的数据采集与适当的分析，交通工程师不可能完成这项任务。

这本手册旨在为交通工程专业学生和交通工程专业人员在数据采集与分析技术方面提供帮助。它表现了几个交通工程主题的入门技术。这些主题既包括了类似地点速度调查、转向流量调查、饱和流率调查等普通调查，也包括了类似控制延误和队列率等新的主题。本手册最好与交通工程学教材结合起来使用。

组织好这些调查，有助于将其纳入到一份正式的交通工程报告中。每项调查都遵从一个传统格式：主题简介、所需设备、一步一步的数据采集程序和一步一步的数据分析。为每个调查项目都提供了数据采集与数据分析格式。这些表格有助于读者完成这项工作，并且为便于使用可以从本手册中撕下来，作为一份报告的组成部分。提出的问题构成了分析的基础并且作为一份格式化报告的结论部分。

在每一个案例中，真实情境分析显现了这种调查可以在哪儿实施以及这种情形下的整体分析。例如，排队长度这一章就对快餐店免下车服务窗口进行了分析。它表明，这些技术怎样应用到类似免下车银行等其他设施。标准公式表明了现场数据采集与现场状态估计之间的联系。这样的联系，使得交通工程专业学生看到估计公式是怎样开发出来的，并且怎样与观测数据进行比较。显然，这样的联系对于学生预测能力来说是有限的。

交通工程专业人员会发现，这本手册通过如何运用这些调查的示例，为各种交通工程调查提供了结构化格式。本手册关注的主题最有可能是实施交通影响调查时所需要的。因此，本手册也包含了类似出行分布与出行生成这样的交通规划主题。本手册未包含交通事故分析，是因为涉及交通事故方面的数据采集与分析的能力，经常取决于当地需求与区域性隐私权政策。当数据采集任务分派给其他人时，针对

这些调查的程序与数据采集表格将有助于数据的组织。另外，分析程序与分析表格将会确保重要项目不会被忽略掉。

每项调查与附录中描述的统计分析方法并不意味着要替代统计学及其相关课程的正规学习。交通工程专业人员基于他们自己或他人的数据采集与分析进行许多决策，概率统计与数值方法作为正规教育的组成部分是必要的。在这些章节和附录中与这些主题相关的材料只是一种提炼，不能作为替代品。还未接受过统计分析正规培训的那些读者，应当在训练有素的导师的指导之下使用这本手册。

致指导教师

希望把使用该手册作为课程教学组成部分的指导教师应当注意，每个主题在数据获得与分析方面的深度与覆盖面都是有限的。课程所使用的主要教材，对每个主题的处理，应当比本手册所容许的空间要详尽得多。它们应当为学生提供其他可能的技术，对为什么需要这些数据，以及该主题是怎样适应大局将有更为详尽的解释。

在整个一个学期的交通工程课程里，按照班级对每项调查进行试验。每个方法都可以借助工科大学生在对材料做适当的理解后用合理的时间来完成。在指定样本量、并恰当地选择调查地点的前提下，每一项调查的数据采集部分都可以在现场用2h以下的时间完成。这样的样本量要求每个调查组有三四名学生，全部组员都参与数据采集工作。

指导教师需要考虑他们的学生是否与动态交通有相互影响。对于专业人员和学生来说，一直要关注在现场工作的安全性。应当提醒学生，在采集信息时应与道路边缘线保持一定的距离。作者的经验显示，应当指派一个学生负责现场交通调查组的安全。也希望其他人使用这种方法。怎么强调数据采集期间的安全性也不过分，应当密切监测整个过程。

作为替代方式，如果认为现场工作太危险，指导教师可以为采集数据的学生考虑其他途径。有许多其他数据源可成功地运用。一个好的学生训练是让学生去研究互联网上的现场视频。其中的一个数据源，就是可以从州交通部门网站上获得现场视频。佐治亚交通厅就维护着全州大量的现场交通监测摄像机，本手册中几乎所有调查的数据都可以从中获得。

类似圣智学习网站上的交通视频图书馆是另外一个数据源。利用不太昂贵的视频记录器，教师或学生工作者就可创建视频图书馆，可以模拟现场数据获得。这些记录并不需要实际现场访问，而是通过利用该城市智能交通系统的一个组成部分——当前视频现场监控来记录。以这种方式观看交通，可以促使课上数据采集，与班级大小或天气状况无关。

数据的另外一个来源，是实际工作人员。学校可以请求许多当地工程师为教学提供相应数据。州和本地交通部门也是好的数据来源。从这些地方获得的数据，对学生来说是特别有意义的。因为它很可能是人们所熟悉的道路和交叉口的数据。在这种情形下，学生不需要进行这些研究工作的数据采集，而仅仅进行数据分析就可以了。

最后，鼓励指导教师利用他们自己的实际经验补充本手册的内容。满足本地条件和地区需求的方法提炼，将提高学生在数据获得与分析质量方面的兴趣。

第 2 版简介

本书第 2 版是对第 1 版内容在时效性、广度与深度等方面进行重新核查的结果。对每一章所阐述的技术方法都进行了复查，并进行了有效性验证，同时，为了反映当前的做法，做了必要的修改。

正如前面提到的，设计这个手册是为了对运输或交通工程课本做一个补充，并拓展课上获得的知识。无论是课程时间使用，还是随后由需要采集数据的专业人员或指导他人采集数据的专业人员使用，该手册都认为用户已经学习过交通工程学以及概率统计，拥有现场方面的基本知识。

随着技术的发展，获得交通数据的方法也应该更先进。在前面介绍中，确定了获得交通数据的几种不同方法，其中包括利用交通视频图书馆和实时交通监测设备。在新版中，较为深入地探讨了这些领域，并且在出版社网站或者这本手册上提供了一些新项目。它们是：

- 为了符合最新版的公路通行能力手册，对分析方法进行了更新。
- 新的“车头时距调查”一章中阐述了确定交叉口交通流品质的新基础。
- 新的“高速公路交通密度”一章中处理了为计算存在少量交叉口道路的交通密度所需数据的采集。
- 预先记录的交通视频是从交通数据采集有利地点摄录的。
- 提供交通图像的交通监测地点清单，适用于数据采集。
- 电子数据表格适用于采集交通数据。
- 分析模板适合下载并应用于数据分析。

为了获得附加的课程资料，请访问 www. cengagebrain. com 网站。利用该网站主页顶端的搜索框搜索 ISBN 号码（本书[⊖]的背面），将会把你带入可以获得这些资源的产品页。感谢认为本书第 1 版有所帮助的读者，你们对第 1 版有价值的反馈和支持，才得以产生第 2 版。特别要感谢如下人员所提供的详尽评价和建议：

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⊖ 此处指原书第 2 版。——编辑注。

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Spot Speed Study
Determining Roadway Speeds

Observing vehicle speeds is one way traffic engineers measure travel safety on roadways. High speeds carry a high risk, whereas low speeds are relatively safe. In addition, observed speeds are used in capacity analysis, accident analysis, geometric studies, determining the need for pedestrian crossings, and in before-and-after studies to assess the effectiveness of roadway modifications. Also, speed observations are compared to the posted speed limit to help determine whether the roadway is in need of greater law enforcement, realignment, or reconstruction. With so many important decisions being based on observed speeds, it is imperative that such speed data be collected correctly and presented effectively.

Many things affect the way drivers behave on the roadway. The proximity of roadside hazards, such as trees and utility poles, the frequency of driveways or curb cuts, and the presence of pedestrians—to name just a few—affect how vehicle operators pilot their vehicles. Since each driver is affected differently, the traffic engineer must look at a spectrum of vehicle-driver combinations, observe how each negotiates travel on the roadway, and define the range of speeds that may be expected at any particular time.

Equipment

The equipment list for the data collection procedure is: a stopwatch, kiel or other marker to mark the pavement, cloth tape or measuring wheel, and note taking materials. If more sophisticated equipment is available—such as hand-held radar or laser—then it can be used to refine the collection procedure.

Data Collection

The procedure to be followed for data collection does not require any special equipment. Although radar detectors and the like can be used, the manual method described here will suffice in most cases if the observer follows the procedure. As an option, this lab may be completed using videotape of the selected